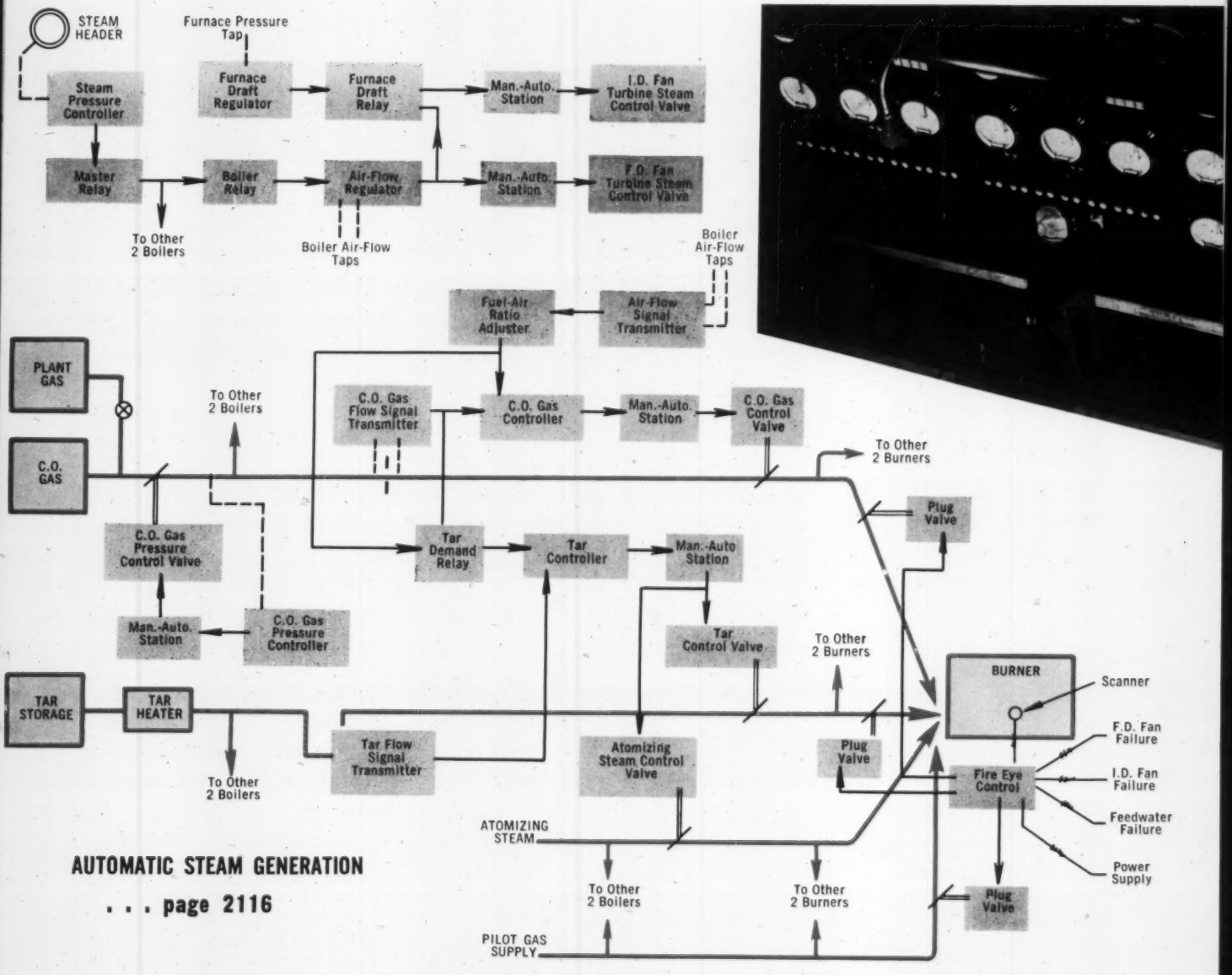
INSTRUMENTS and AUTOMATION



AUTOMATIC STEAM GENERATION

. . . page 2116

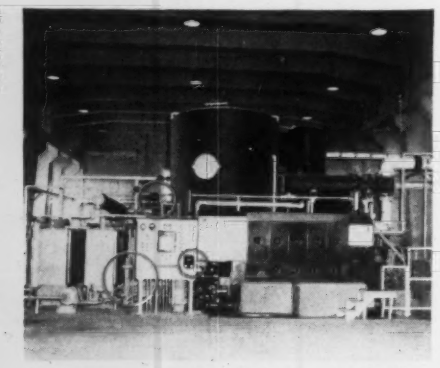
Vol. 28, No. 12
DECEMBER 1955

***Including:* The Journal of the SCMA *and* Simulation Council Newsletter**

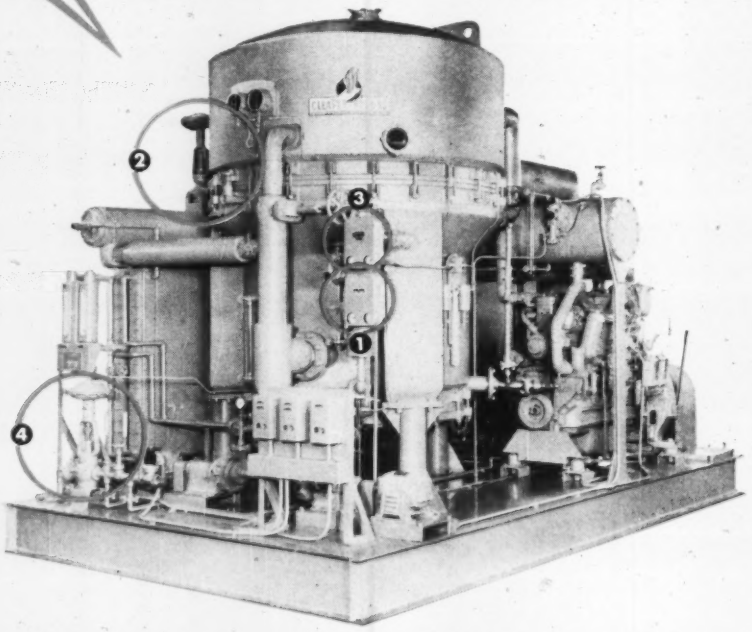
SIMULATION COUNCIL

This Cleaver-Brooks Unit Converts –

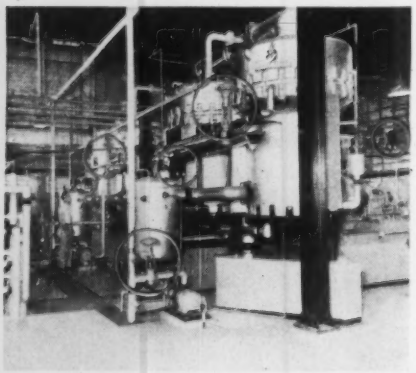
SEA WATER INTO FRESH WATER



At the time of its installation at the Kindley Air Force Base in Bermuda, this Cleaver-Brooks unit and three others like it constituted the world's largest vapor compression sea water distillation plant. Total daily capacity of the installation is more than 200,000 gallons. BS&B Automatic Controls are standard equipment on all units.



This Cleaver-Brooks Diesel Drive Compression Still produces more than 14,000 gallons of U.S.P. chemically pure and pyrogen free water per day from brackish or sea water. It is automatically controlled by (1) a BS&B Type 1400LP Low Pressure Pilot which operates (2) a BS&B Type 86R Valve to control the evaporator pressure, and by (3) a BS&B Type 887 Liquid Level Controller which operates (4) another BS&B Type 86R Valve to control the evaporator liquid level.



Largest compression still installation in the United States for producing distilled water is this West Coast metropolitan area plant which commercially produces more than 100,000 gallons of distilled water daily. All units are Cleaver-Brooks. Note BS&B Automatic Controls visible in the picture.

. . . With The Help Of

BS&B AUTOMATIC CONTROLS!

When a manufacturer of heavy industrial heating and process equipment selects the automatic controls to be used as "original equipment" on his units, he must be *certain* that they will operate just as efficiently and dependably as the unit they are to serve.

That is why Cleaver-Brooks Company, of Milwaukee, and many other manufacturers have standardized on BS&B. They know that BS&B Automatic Controls can *always* be counted on for precise accuracy, superior quality, long life and outstanding performance!

Why not make BS&B Automatic Controls your *first* choice too – both for "original equipment" and for replacements? Your BS&B Representative will be glad to give you detailed information. Or you may write to . . .

BLACK, SIVALLS & BRYSON, INC.

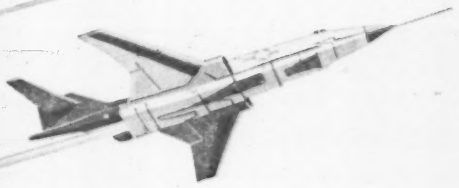
Controls Division, Dept. 4-V12

7500 East 12th Street Kansas City 26, Missouri

For more information circle 1 on inquiry card.

which way* to measure jet engine performance?

KOLLSMAN PRESSURE RATIO THRUSTMETER
used on Convair's F-102 and McDonnell's F-101



thrustmeters

to indicate PRESSURE RATIO...to indicate DIFFERENTIAL PRESSURE

Actual photograph

KOLLSMAN is in production...

on components for BOTH TYPES—for Remote or Direct reading

For over a quarter century, Kollsman has been making precision pressure sensitive mechanisms using displacement type diaphragms. This diaphragm can be called the heart of a thrustmeter pressure indicating system.

Our long experience making displacement type diaphragms guarantees reliable thrustmeters.

Proven Kollsman displacement type diaphragms, when fitted with Kollsman Synchrotels, comprise the transmitters for remote indicating types. Thousands of Synchrotels are now in use in other applications equally demanding of accuracy and durability.

Tailor-made Thrustmeters can be supplied for any engine-airplane combination. Write for complete technical information.

TYPICAL SYSTEM OPERATIONAL DATA

1. Accuracy: .015 in 100% of readings at room temperature.
   .025 in 85% of readings at −55°C and +70°C.
   .035 in 15% of readings at −55°C and +70°C.
2. Altitude: No specific limitation.
3. Power: 115V, 400CPS, single phase, 18VA
4. Pressure Ratio Range: 1.2 to 3.4
5. Pressure Ranges (operating):
   Pt_2=2 to 50" Hg. Abs.
   Pt_2=2.4 to 100" Hg. Abs.
   Pt_7-Pt_2=0.4 to 70" Hg.
6. Temperature Range: −55°C to +120°C
7. Weights:
   Transmitter: 2.2 lbs.
   Indicator (including integral amplifier): 1.8 lb.
8. Response: Full Range in 7 seconds.

**The Pressure Ratio System has advantages for indicating optimum climb and cruise throttle setting, whereas the Pressure Differential System has a definite advantage at take-off.*

Kollsman activities cover these seven fields:

AIRCRAFT INSTRUMENTS • PRECISION CONTROLS
PRECISION COMPUTORS AND COMPONENTS • OPTICAL COMPONENTS AND SYSTEMS
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INSTRUMENTS FOR SIMULATED FLIGHT TRAINERS

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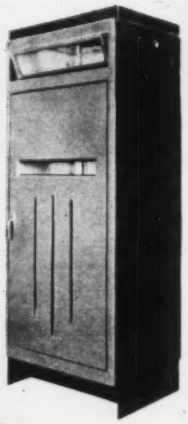
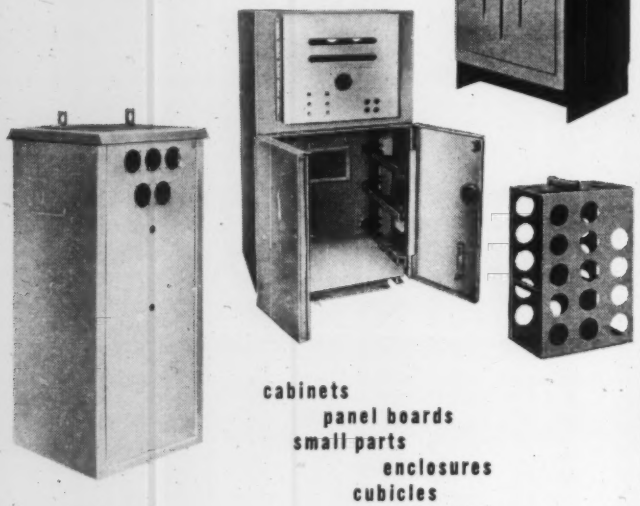
80-22 45th AVE., ELMHURST, NEW YORK • GLENDALE, CALIFORNIA • SUBSIDIARY OF Standard COIL PRODUCTS CO. INC.

For more information circle **2** on inquiry card.

if it's **METAL FABRICATION**

your **FALSTROM** man has the answer!





cabinets
panel boards
small parts
enclosures
cubicles
housings
chassis
consoles

- fabrication of large or small shapes to close tolerances.
- fabrication in aluminum, sheet steel, stainless steel, copper, brass and other alloys.
- complete design-engineering-production service.
- stock tools, dies, jigs . . . standard fabricating techniques employed wherever possible.
- modern facilities for punching, shearing, bending, welding, finishing.

Falstrom means it's that much better!

FALSTROM

FALSTROM COMPANY, 92 Falstrom Court, Passaic, N. J.
PRescott 7-0013 **Since 1870**

For more information circle **3** on inquiry card.

Sensitive Research

ELECTROSTATIC VOLTMETERS

True *RMS* reading instruments with an *Input Resistance* of 1×10^{14} ohms and an accuracy of 1% on *DC and AC to R.F.*

Model ESH

Ranges from 5 KV to 60 KV in single and multirange instruments. 6 inch hand drawn scale. Correspondence invited on ranges to 100 KV.

Model ESD

Ranges from 120 V. to 5,000 V. in single and multirange instruments. 5.2 inch hand drawn mirrored scale. Completely portable.

Model VPA

Peak voltage unit to adapt any SRIC electrostatic voltmeter to an accurate peak reading voltmeter which takes a minute amount of power from the circuit under measurement.

Inquiries Invited –
Write Dept. IA 5.

SENSITIVE RESEARCH INSTRUMENT CORPORATION
NEW ROCHELLE, N. Y.

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INSTRUMENTS and AUTOMATION

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G-E PRECISION INDICATOR is available as a single-point or multiple-point instrument. For multi-point instruments different types of switches are available. The toggle type, pictured above, is either locking or non-locking, according to specifications. The push-button type remains in a depressed position until another button is pushed. The large easy-to-read scale supplies quick temperature readings for accurate records and makes logging a simple job for the operator. For further information contact your nearest G-E representative or send in coupon at the right.

USE G-E PYROMETERS FOR ACCURATE CONTROL

General Electric Pyrometers Give Dependable Protection

TYPE HP-3 PYROMETER, a two-position controller, has positive control action, initiated by 0.1 percent in full scale movement of instrument pointer. This gives accurate readings from easy-to-read 7-inch scale. Units are available for flush or surface mounting. Indicator, controller, and protector units are plug-in type, permitting easy servicing.

New G-E Precision Indicator Makes Temperature Checks Quick and Easy

New G-E Instrument Gives Finger-tip Scanning of up to 48 Process Temperatures in Helping You Maintain Accurate Product Control

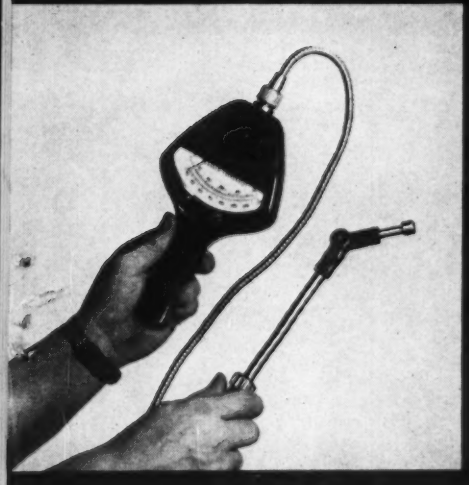
General Electric's new precision indicator scans, by manual switching, from 1 to 48 process temperatures on multi-installations of thermocouples or resistance-bulb circuits. The new G-E potentiometer features a wide temperature range scale and is a high-accuracy, null-balancing instrument.

NEW G-E INDICATOR assures you of having less maintenance by eliminating conventionally used dry cells, slidewire and sliding contacts. This excludes such time-consuming jobs as replacing dry cells, or cleaning moving contacts.

THE MAGNETIC STANDARD provides truly continuous standardization through a revolutionary measurement-circuit design, which incorporates the high stability of a permanent magnet for a reference standard. Loss of measurement and control during standardization periods can never be experienced with constantly balancing G-E system.

G-E RECORDING CONTROLLER has same measurement-circuit design as precision indicator. Long term accuracy and precision of measurement are assured, and you get continuous dependable control with truly continuous standardization.

G-E HAND PYROMETER DESIGNED FOR WIDE USE



GENERAL ELECTRIC COMPANY
SECTION F 587-1
SCHENECTADY 5, NEW YORK

Please send me a copy of the interesting and colorful bulletins checked below:

- ☐ GEA-6020 Hand Pyrometer
- ☐ GEC-713 Thermocouple and Accessories
- ☐ GEC-1311 Type Precision Indicator
- ☐ GED-2100 New Recording Controller

Name .....
Company .....
Street .....
City ..... Zone ..... State .....

DUAL-RANGE General Electric hand pyrometer is designed for more flexible and inexpensive measurement of gas, surface and molten-metal temperatures.

EASY-TO-USE hand pyrometer accurately indicates temperature of precision castings. The instrument is light in weight with a non-slip, bayonet-grip handle.

Progress Is Our Most Important Product

GENERAL ELECTRIC

For more information circle 5 on inquiry card.

COSTS NO MORE THAN ORDINARY OSCILLOGRAPHS

Even though the new General Electric PM-20 general-purpose oscillograph has many features not found on comparable oscillographs, it is priced at only $4,200* net.

A WIDE RANGE of frequencies—from d.c. to 6,000 cps—can be recorded at speeds from 0.8 to 100 inches/sec with the new oscillograph.

AUTOMATIC RECORD NUMBERING, timing lines, trace interruption for identification, and automatic record-length control are a few of the many additional features provided for convenient operation.

*Galvanometers and magnet assembly are not included.

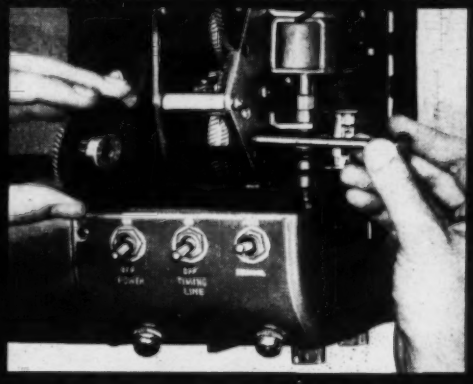
PM-20 OSCILLOGRAPH

4 **EASY-ACCESS DESIGN** facilitates fast operation and maintenance. Both galvanometer banks and the gear train are

GENERAL ELECTRIC ANNOUNCES . . .

New Industrial Oscillograph with 5 Exclusive Features

FOR DYNAMIC OR STATIC TESTING OF AIRCRAFT AND INDUSTRIAL EQUIPMENT . . .

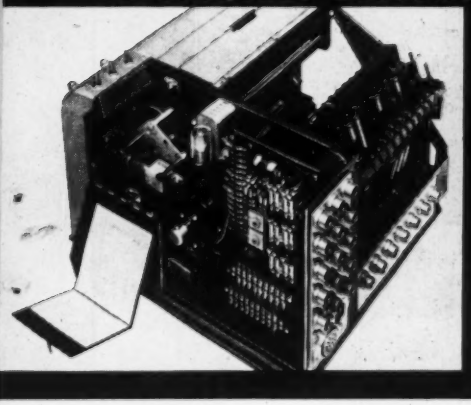


1 **71-GALVANOMETER CAPACITY** in two banks gives versatility in measuring and recording many variables simultaneously.

2 **ONLY 2 IDLER GEARS TO CHANGE** and both are always in use eliminating storage and the chance of loss. No tools are necessary to move the gears.

3 **MAGNETIC SPOOLS** in the record holder simplify loading. The spools automatically position themselves in the record holder.

IS UNIQUELY DESIGNED FOR EASY OPERATION AND MAINTENANCE



GENERAL ELECTRIC COMPANY
SECTION G585-C
SCHENECTADY, N. Y.

Please send me the following bulletin:
PM-20 General-purpose Oscillograph (GEA-6348)

Name .....

Company .....

Street .....

City ..... **Zone** ..... **State** .....

readily accessible through hinged doors in the lightweight aluminum case. The entire cover may be removed by loosening three fasteners.

5 **SEPARATE VIEWING LAMP** eliminates adjustments of recording lamp intensity for viewing. Lamps are easily accessible by removing the record holder.

FOR MORE INFORMATION, contact your nearest G-E Apparatus Sales Office or use the coupon above to request a copy of bulletin GEA-6348.

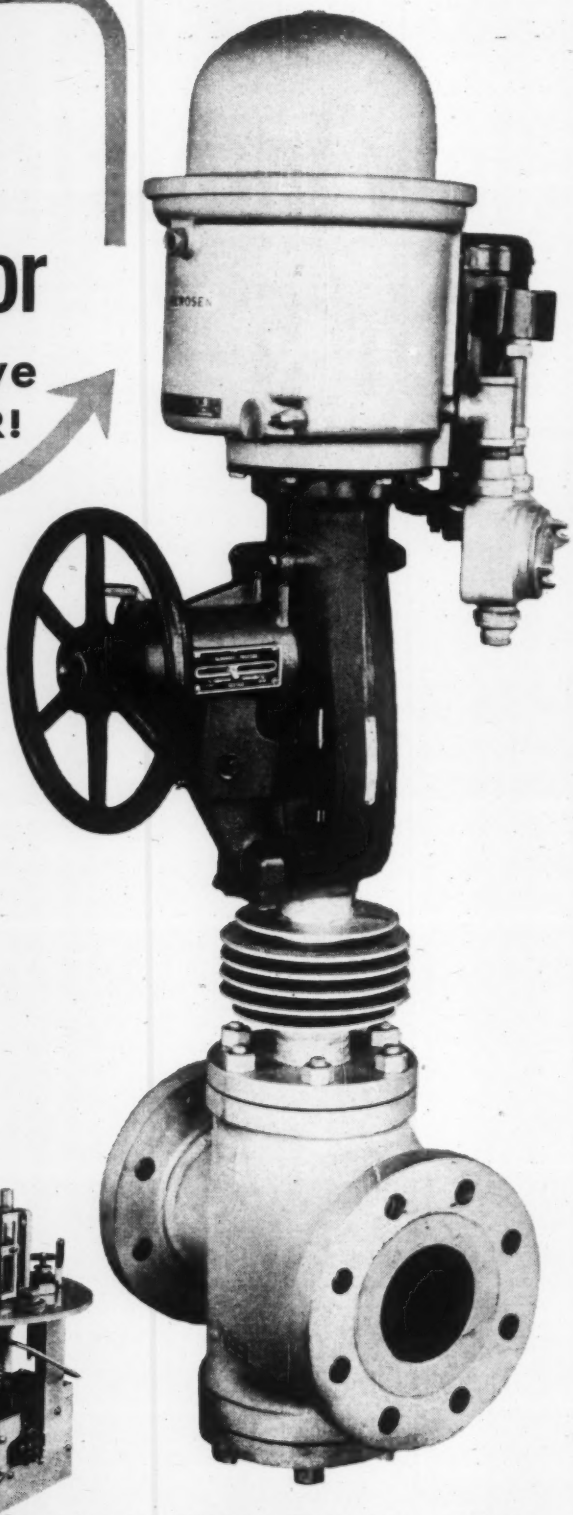
Progress Is Our Most Important Product

GENERAL ELECTRIC

For more information circle 6 on inquiry card.

NEW control valve operator

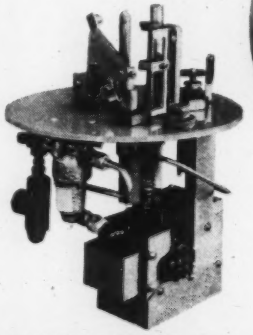
accurately positions valve WITHOUT COMPRESSED AIR!



Controllers for process variables like pressure, temperature, flow, and liquid level can now be manipulated without air supply and compressor systems. The new 'American-Microsen' Control Valve Operator positions conventional slip-stem control valves with positive *electro-hydraulic* action. It now makes available a fully-integrated, graphic-type process control system *operated entirely by electricity*. It accepts the 0.5 to 5.0 ma. d-c signal of the 'American-Microsen' Electronic Process Control System. Signals received by the Valve Operator may include proportioning, reset, and rate actions to control, ratio, program, etc. There is no valve "flutter", even with greatly varying stem thrust; and position accuracy is quickly established by an integral electronic feedback system.

The Control Valve Operator is especially desirable where transmission distances are long . . . where freezing or clogging of pneumatic lines are problems . . . where the cost of air supply systems is excessive. Controls and Valve Operator can be up to 30 miles from the transmitter; the high-level signals are unaffected by ordinary transmission variations or ambient conditions.

Learn exactly how the new 'American-Microsen' *Electro-Hydraulic* Control Valve Operator can contribute to your process efficiency, product quality, and profitable operation. Write for data.



Interior working view

MANNING, MAXWELL & MOORE, INC.

INDUSTRIAL CONTROLS DIVISION, STRATFORD, CONNECTICUT

MAKERS OF 'AMERICAN-MICROSEN' ELECTRONIC TRANSMITTERS, INDICATING OR RECORDING SET STATIONS, CONTROLLERS, MANUAL CONTROL STATIONS AND ELECTRO-PNEUMATIC VALVE POSITIONERS.

MANNING MAXWELL & MOORE INC. M&M TRADE MARK

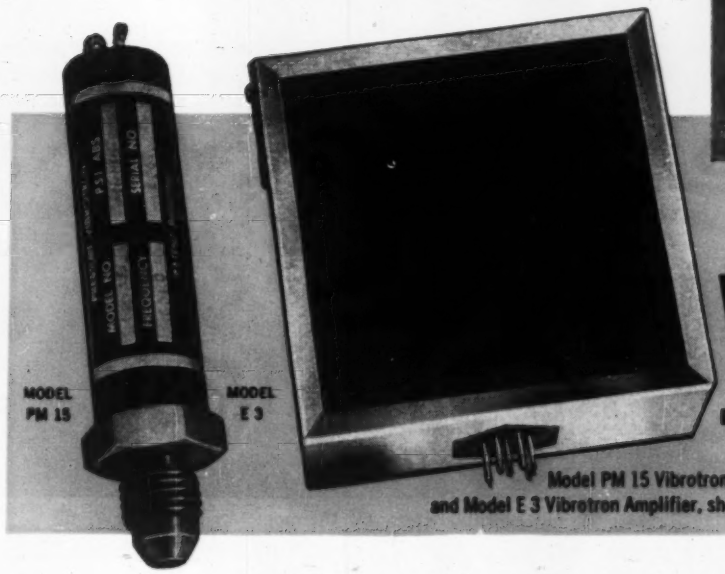
For more information circle 7 on inquiry card.

MEASURES IN NUMBERS

...NOT VOLTS!

For FM/FM Telemetering and Multiplexing Systems

BJ



Model PM 15 Vibrotron Pressure Gage and Model E 3 Vibrotron Amplifier, shown actual size

vibrotron

DIGITAL PRESSURE GAGE

Accurate enough to fit into any telemetering system that requires precise measurement of static or dynamic pressure... and small enough to fit into the palm of your hand... Byron Jackson's new Vibrotron Pressure Gage sets a new standard of accuracy by measuring in numbers, not volts!

ACCURATE AND RELIABLE Standard Vibrotron Gages provide accuracies to .1% under the temperature and pressure conditions encountered from sea level to 75,000'.

DIRECT AND SIMPLE Utilization of the vibrating wire principle which directly produces a subcarrier frequency eliminates subcarrier oscillators and consequent drift and inaccuracy. The direct digital information is easily handled by tape recording and data handling systems.

VERSATILE AND STABLE *For altitude measurements*, the standard Vibrotron Gages will resolve 60' at sea level. Special gages that cover 0-1 psi absolute ranges or less are also available for better resolution. *For air speed measurements*, a variety of differential gages have been developed to measure the wide ranges of speeds needed for aircraft and missile work. *For pressure measurements*, corrosion-resistant gages are being supplied to measure static or dynamic pressure of virtually any medium including fuming acids.

Available in eight pressure ranges from 0-3 psi to 0-2000 psi and in the following RDB Channels.

CHANNEL	CPS	% DEVIATION
8	3000	±7½%
9	3900	±7½%
10	5400	±7½%
11	7350	±7½%
12	10500	±7½%
13	14500	±7½%
14	22000	±7½% or 15%
	40000	±15%
	70000	±15%

BJ

SINCE 1872

Byron Jackson

DIVISION OF BORG-WARNER CORPORATION

492 EAST UNION STREET • PASADENA 1, CALIF. • RYAN 1-5166

PACEMAKER IN PRECISION ELECTRONICS

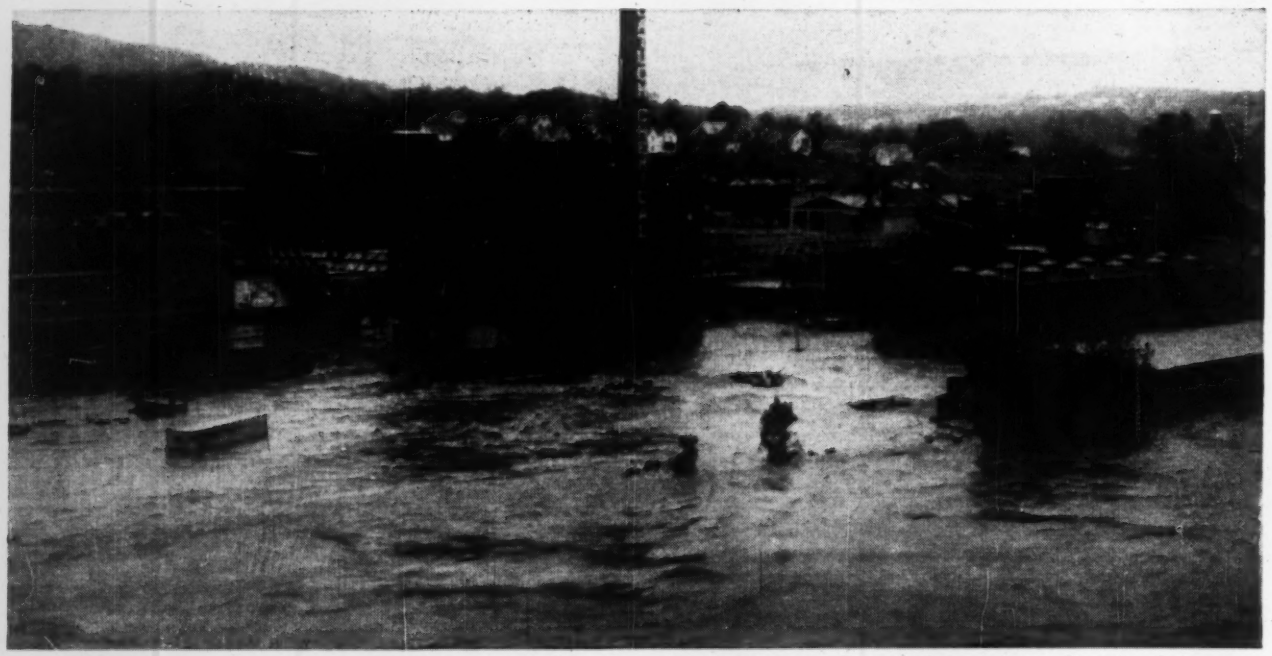
WRITE TODAY for complete specifications and information on how Byron Jackson engineers can work with you on (1) application of standard Vibrotron models to your measurement problems; (2) special Vibrotron development; and (3) design of complete systems.

For more information circle 8 on inquiry card.

BRISTOL FIELD SERVICE...

Bright spot in a

Height of flood at American Brass Company, Casting Shop, Torrington Division. More than 125 instruments were serviced in this customer's Naugatuck Valley plants. In addition, instruments returned to Bristol for repair included: 17 electronic potentiometers, 62 thermometers and gauges, 69 running count recorders, and 47 electric controllers. First instruments were returned to customer in 6 days; all others were returned by the customer's deadline.



More than 150 instruments serviced in inundated plants of United States Rubber Company, plus 10 electronic instruments, 31 thermometers and gauges, 9 electric controllers, 5 pneumatic controllers which were removed to Waterbury for service. First instruments returned to customer in 3 days; all returned by customer's deadline.

For more information circle 9 on inquiry card.

Black Friday

Bristol engineers give flooded areas fast repairs without slowing service to other areas

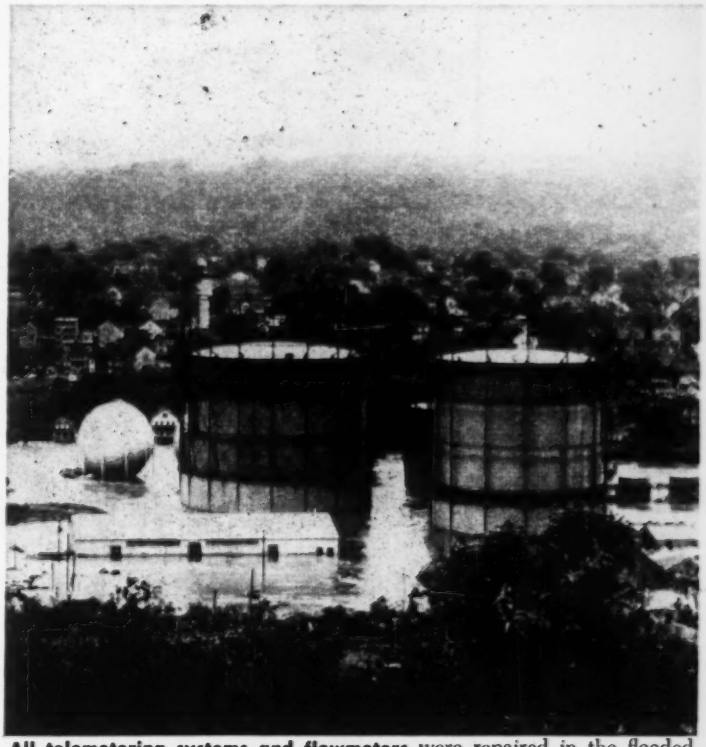
On Friday, August 19, 1955, raging flood waters in the wake of hurricane Diane inundated and battered hundreds of East Coast industrial plants, heavily damaging buildings and equipment.

Fortunately, though our bridge was lost and utilities were cut off for a few days, the Bristol Company at Waterbury, Connecticut, escaped damage.

Repair service on the double

Even before the flood waters receded, Bristol service engineers were on the job, repairing the hundreds of Bristol recording and controlling instruments damaged by water, silt and debris, contributing in an important way to the recovery of this stricken area—with no sacrifice to Bristol customers in other parts of the country.

Working in mud and filth, Bristol servicemen repaired instruments right in the plant wherever possible. Where heavier damage took place, instruments were returned to Waterbury for repair or replacement. Back-in-service records for three heavily hit plants are shown on these pages, together with pictures of the flood damage.



All telemetering systems and flowmeters were repaired in the flooded plants of a large public utility in Connecticut. Eight thermometers and gauges too badly damaged for repair were replaced. All instruments delivered to customer in seven to nine days!

Every customer's deadline was met

HUNDREDS OF INSTRUMENTS from plants other than those shown were also serviced. They were repaired in the plant, if possible, or picked up in the most convenient location for the customer, repaired at Bristol, then returned and reinstalled. The deadline set by the customer was met in every case. Instruments were often replaced and operable before the remainder of the plant.

Flood or no flood, this is the kind of service you can expect when you deal with Bristol. In 38 cities across the U. S. and Canada, Bristol service centers, with factory-trained servicemen, stand ready to solve your every maintenance or repair problem. From coast to coast you are as close to your Bristol service center as to your telephone. The Bristol Company, 113 Bristol Road, Waterbury 20, Conn. 5.46

BRISTOL

POINTS THE WAY IN HUMAN-ENGINEERED INSTRUMENTATION

AUTOMATIC CONTROLLING, RECORDING AND TELEMETERING INSTRUMENTS

For more information circle 9 on inquiry card.

Bailey Recorder for receiving pneumatic and electric signals.

Measured Variables
% combustibles
combustion
conductivity
density
differential
draft
flow
liquid level
% oxygen
pH
position
pressure
ratio
smoke density
specific gravity
speed
temperature
vacuum

Pick any four, plug in, and record

Here is a receiver recorder, custom-built *by you* to meet your needs, no matter how changeable, how complex. On a single chart you can record any four measured variables—and interchangeable receivers permit new combinations almost at will.

Individual plug-in pneumatic or electronic receivers—and corresponding integrators—are interchangeable in the four identical frame slots. You can select any combination; even including two receivers and their two integrators.

Think what this can mean to you! Parts inventories are minimized; re-use of components keeps instrumentation costs economically low when cycle changes are frequent—and you can even tie in with your existing transmitters.

Ask for Product Specification E12-5.

ONLY BAILEY OFFERS ALL THESE ADVANTAGES IN A SINGLE RECORDER

- Pre-calibrated plug-in receiver units
- Up to four pneumatic or electronic receivers —or two receivers and two integrators
- Any four variables on one chart—easily read and interpreted
- A full year's ink supply at one loading
- Faster ordering—from stock
- Minimum inventory of parts
- Minimum instrument investment for process cycle expansion or alteration

BAILEY
METER COMPANY
1041 IVANHOE ROAD
CLEVELAND 10, OHIO
Controls for Power and Process

BAILEY METERS
Controls for
TEMPERATURE
PRESSURE
GAS ANALYSIS
FLOW LEVEL
RATIO DENSITY

For more information circle **10** on inquiry card.

For the THIRD INTERNATIONAL AUTOMATION EXPOSITION

New York City, November 26-30, 1956

A NEW TRADE SHOW BUILDING

at 500 Eighth Avenue, New York City

Third International Automation Exposition will occupy five floors—2nd, 3rd, 4th, 5th, and 6th.

Rest rooms on each floor . . . water coolers in four corners of each floor . . . restaurant and bar in the building.

A NEW TRADE SHOW CONCEPT

Each "booth" an individual **air-conditioned** room . . . can be locked at close of show each day . . . . each exhibit **visible** from hall.

Refreshments can be served **in** the rooms; also will be available from serving carts **during open hours of the Show.**

Special shelving for each room optional at NO CHARGE . . .

Exhibitor personnel may set up **own exhibit;** additional labor also available through the service desk

Crate storage in basement **or in exhibitor's own display room.**

AUTOMATION HANDBOOK

FREE space (7x10" page for each booth) in the HANDBOOK enables all exhibitors to describe the products in their exhibit—thereby extending the effectiveness of their participation in the Show. All registrants receive a copy.

A NEW LOW COST FOR EXHIBITORS

All-inclusive price of $4.00 per square foot includes: Handling exhibit material from receiving platform of building to your booth; electric current (to 3,000 watts); general lighting (about 50 foot-candles); one spotlight; furniture (2 tables, 2 chairs, 1 smoking stand, 1 costumer); telephone; crate storage; name sign; asphalt tile floor; cleaning; and handling exhibit material from booth to shipping platform at end of show.

*Second floor is an open exhibit area laid out in usual booth style.

Exhibitors in the Second International Automation Exposition have a priority in the choice of their exhibit space at the Third International Automation Exposition. New York City, November 26-30, 1956.

A NEW ULTRA-CONVENIENT LOCATION

500 Eighth Avenue, between 35th and 36th Streets, New York City.
One block from the Pennsylvania and Long Island Railroad Stations
Tunnel connection from Station, Statler Hotel, and 7th Avenue Subway

8th Ave. Subway Station at corner
1 block from 7th Ave. Subway Station
1 block from Crosstown buses on 34th St.
2 blocks from Statler Hotel
3 blocks from Governor Clinton Hotel
4 blocks from West Side Highway
4 blocks from Lincoln Tunnel
5 blocks from International Bus Station
8 blocks from Queens Midtown Tunnel
8 blocks from Domestic and West Side International Air Terminals
15 minutes from Grand Central Station
20 minutes from Washington Bridge

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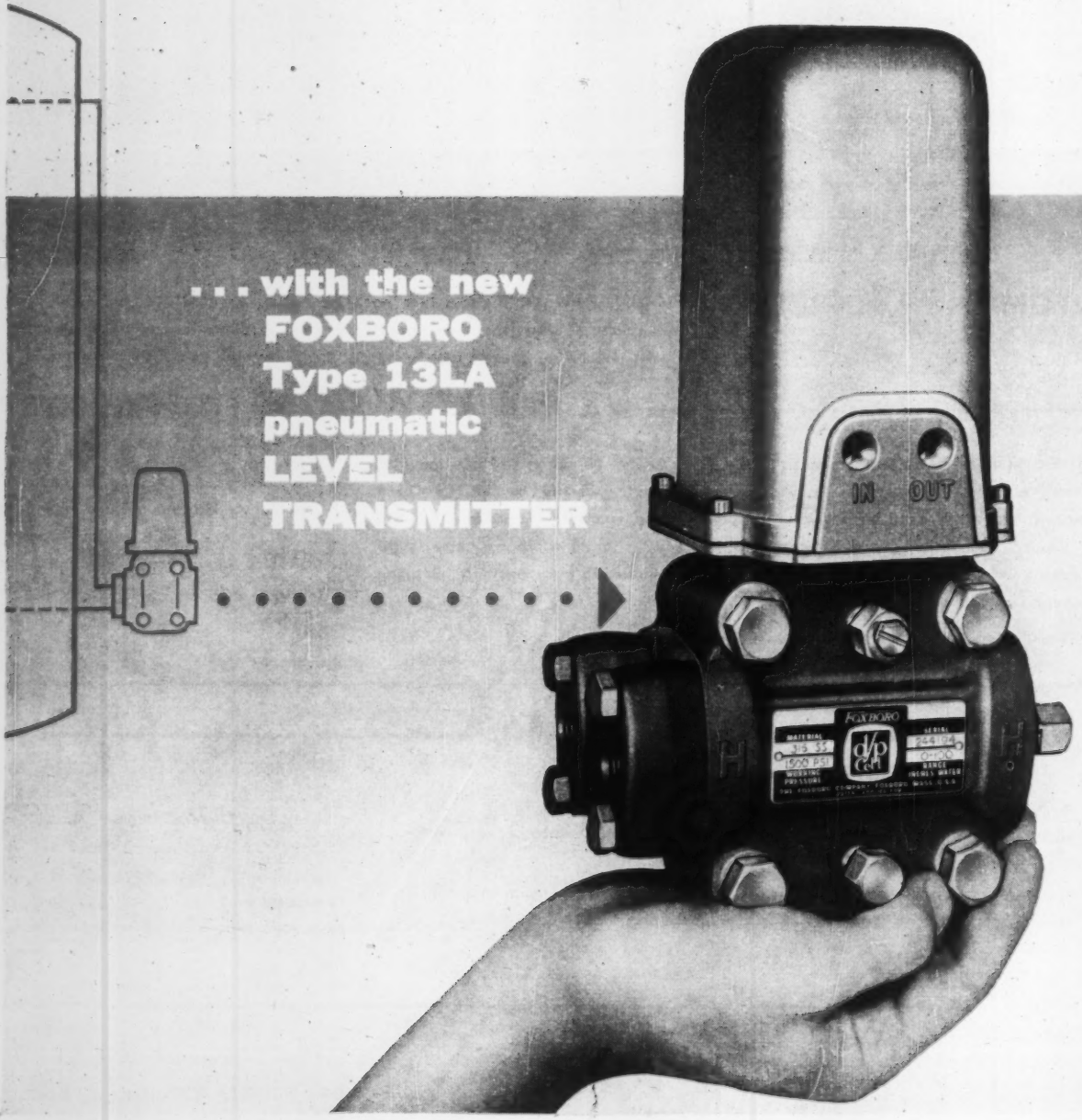
NEW SIMPLICITY

FOR LIQUID LEVEL

. . . with the new
FOXBORO
Type 13LA
pneumatic
LEVEL
TRANSMITTER



For more information circle **12** on inquiry card.

MEASUREMENT !

Easy Low-Cost Installation on any closed or open tank. Only two small pressure taps required. Nothing inside tank!

Fully-Adjustable Ranges . . . 0-20" to 0-80" and 0-50" to 0-250" H_2O.

Complete adjustment for elimination of outside leg effect gives forward-reading signal to any standard receiver!

Highest Sustained Accuracy . . . Instant, precise response to level changes even under extreme operating conditions.

Rugged and Corrosion-Resistant . . . Level-sensing element is Type 316 stainless steel, silicone-filled "capsule" diaphragm applicable on static pressures up to 1500 lbs.

There's nothing simpler for accurately measuring liquid level than the Foxboro Type 13LA d/p Cell* Liquid Level Transmitter! No floats, knife edges, stuffing boxes, or complicated hook-ups. A simple, direct piping job connects it to the tank . . . operates in any position, even upside down. The Transmitter precisely measures difference in head caused by level change . . . sends 3-15 psi air signal over single air line to indicator, recorder, or controller. It's easily traced when required, up to 250°F., to maintain fluidity of liquid.

The 13LA d/p Cell Transmitter is low in initial cost, requires practically no maintenance. In addition, it is easily converted in field for the measurement of fluid flow. It's the ideal instrument for heavy industrial applications . . . indoors or out. For complete details, ask your nearest Foxboro Sales Engineer, or write for new Bulletin 13-22 to **The Foxboro Company, 4612 Neponset Ave., Foxboro, Mass., U.S.A.** *Reg. U. S. Pat. Off.

FACTORIES IN THE UNITED STATES, CANADA, AND ENGLAND

FOXBORO REG. U. S. PAT. OFF. LIQUID LEVEL TRANSMITTER

For more information circle **12** on inquiry card.

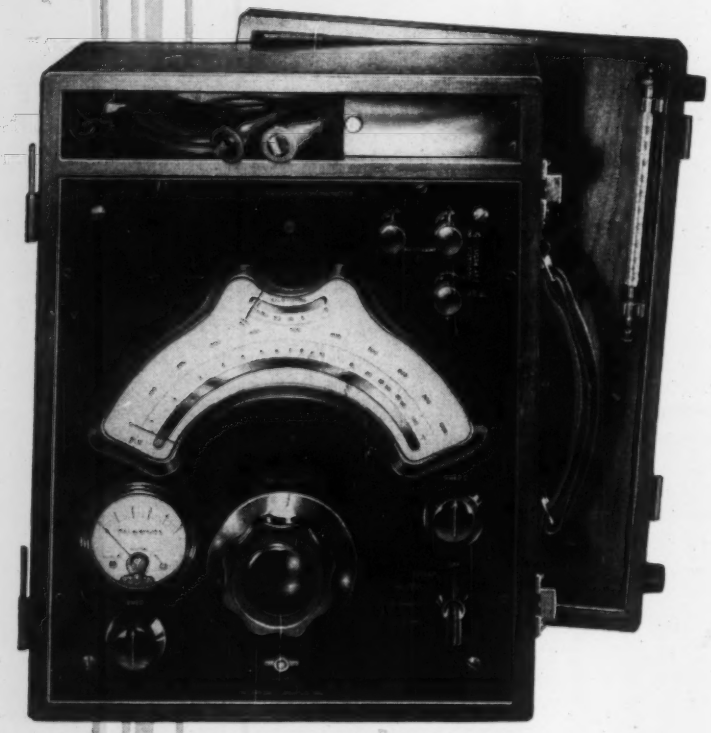
AN ACCURATE, PORTABLE, MULTI-FUNCTION INSTRUMENT

THE LEWIS *PORTABLE* TEST POTENTIOMETER

for Service Testing Exhaust Temperature Measuring Systems

Developed for use by field service engineers of a leading engine manufacturer, the Model 13P05 Test Potentiometer has proven its serviceability in desert heat and arctic cold at maintenance bases on many points of the globe.

FOUR PRECISION INSTRUMENTS IN ONE!



Model 13P05

For dependable maintenance, use test equipment made by the manufacturer of the components to be checked.

A PYROMETER-POTENTIOMETER
for measuring exhaust thermocouple temperatures that is truly portable with a sturdy pivoted galvanometer and without a standard cell. Accurate automatic electrically operated cold junction compensation permits this instrument to be used in ambient temperatures from below freezing to plus 120°F. Mirror scales with precise hand-drawn graduations and knife edge pointers insure accurate readings from zero to 1000 degrees Centigrade.

A LOW RANGE OHM-METER
with a widely spaced, hand drawn scale for checking the resistance of leads, thermocouples and balancing resistors to insure correct adjustment to match external resistance requirements of exhaust temperature indicators, either eight or twenty-two ohms.

A KILO-OHM METER,
energized by a 67½ volt battery for checking insulation resistance of lead-wires and thermocouples. Due to the potential applied, this circuit is more effective in detecting flaws than conventional ohm meters. A hand-drawn scale is clearly marked in kilo ohms resistance.

A THERMOMETER TESTER
for precise scale error checks of exhaust temperature indicators having either eight or twenty-two ohms external resistance. A controlled power supply energizes the indicator under test, through the correct series resistance, and the zero to 1000°C temperature scale is used as a reference standard. Recommended for use in adjusting exhaust indicators in accordance with ambient temperature, with power applied for 700°C, through the proper resistance. A liquid-in-glass thermometer and flexible test leads are supplied with each instrument.

LEWIS ENGINEERING CO.

NAUGATUCK, CONNECTICUT

For more information circle **13** on inquiry card.

Trends...

INSTRUMENTS and AUTOMATION

Electron microscopes have been used in industrial laboratories for about 15 years, says A. D. Little Bulletin, and about a thousand instruments have been built to date.

Trend in research is to teamwork approach, yet mortality of ideas is high, says booklet of Commercial Chemical Development Association. Each successful new product is preceded by 540 ideas at research level, 92 at the laboratory stage, and 8 at semi-works stage.

Chemical industry business is outlined in SRI's Chemical Economics Handbook; 32 major industry groups are treated, including 14 chemicals (organic, inorganic, plastic, synthetic rubber, explosives, drugs, soap and glycerine, paints, gum and wood chemicals, fertilizers, vegetable oils, animal oils, misc.) and 2 allied fields (petroleum and coke). Annual volume of chemicals in 1947 was $13.9 billion; 1954 volume was $22.4 billion. Plastics materials expanded by 84%; soap and glycerine by 8% between 1947 and 1954.

Leisure industries should benefit from automation. Board-game industry reported about $40 million annual retail sales in 1954.

Automatic merchandising is expanding field. In 1946 automatic vending machines for candy, drinks, cigarettes, etc., sold $600 million worth of goods; in 1953 sales were $1.5 billion; by 1960 sales are expected to exceed $3 billion. Europe uses automatic vending to greater degree than USA.

Ultrasonic dental unit (Cavitron) is being investigated by 150 universities, hospitals and dentists.

Instrumentation in medical labs and hospitals is expanding. Sloan-Kettering Institute for cancer research in N. Y. reports use of instruments with value of $290,000. Associated hospitals use instruments in excess of $800,000.

Radioactivation of surface for investigation of wear (as in dies) is new field. ASME Paper 55-SA-24 reports technique.

Radioisotope use is expanding in radiographic inspection of pipeline welds; also in many laboratory research experiments.

There are now 3000 industrial laboratories in USA; in 1915 there were 100. Research now uses about 1.25% of gross national product; figure was 0.8% in 1950; 0.6% in 1945; 0.3% in 1940.

Cost of research varies widely with industry: Aircraft industry devotes 13% of sales to research, instrument industry 5.8%, chemicals 2.5%. Average for all industries is 2.0%.

Growth of contract research is startling. Nearly 3000 companies use services of nonprofit research institutes. See pages 2098-2101 for details.

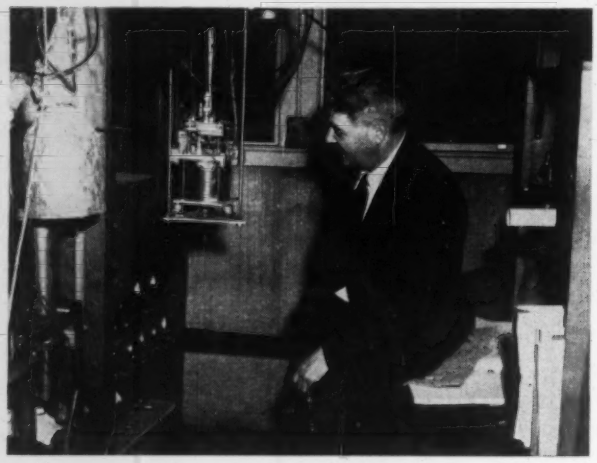
The instrument department of today is the plant control center of tomorrow—R. Rimbach.

News...

INSTRUMENTS and AUTOMATION

The Cesium Atomic Frequency Standard

CAMBRIDGE, MASS.—An atomic clock, the Cesium Atomic Frequency Standard, has been developed by Dr. Jerrold R. Zacharias, director of the Laboratory for Nuclear Science at MIT. He is working on a model so precise that if it had been ticking away since the time of



Christ it would now be only one-half second "wrong." Commercial models of the clock will be available soon for many uses.

The clock's primary use will be in scientific research, (the inventor plans a test of Einstein's General Theory of Relativity, by which it is supposed that gravity would cause two clocks, one on top of a mountain and one at the foot, to vary in time-keeping), navigation (for locating ship position closer than five or ten miles as by present methods), astronomy, geophysics, and communications.

Time-keeping in the device is controlled by the oscillation of electrons in the cesium atom which has a frequency of approximately 9192.632 megacycles per second; this frequency serves as the unit of time in the atomic clock.

One hundredth of a gram of cesium (about the size of a pinhead), is enclosed in a metal crucible. Subjected to heat about 100°C, the cesium shoots a stream of atoms through a hole in the crucible. The atoms strike a detector screen and their frequency is reported through complex apparatus. Weight loss is only about one millionth of a gram per day and, for all practical purposes, the clock is perpetual. The Atomic Frequency Standard is accurate to one part in ten to the tenth power, or 10,000,000,000. Dr. Zacharias expects, through further development, to obtain accuracy of one part in ten to the twelfth power.

Gerald G. Lipke

Gerald G. Lipke

Gerald G. Lipke, sales manager for standard products, Hagan Corporation, Pittsburgh, Pa., and his wife, Patricia Wright Lipke, were among the 44 persons killed in the explosion and crash of an air liner in Colorado on November 1. Mr. Lipke, 41, joined the Pittsburgh instrument and control firm in 1936 as a service engineer for Hall Laboratories, Inc., a Hagan subsidiary. He was named sales manager of standard products in 1954. "Jerry" was well known in the process instrument field, and the Instruments Publishing Company joins in mourning the loss of a good friend.

Iron & Steel Conference

PITTSBURGH, PA.—The Pittsburgh Section, Instrument Society of America will hold its Sixth Conference on Instrumentation in the Iron and Steel Industry on March 5 and 6, 1956, in the Hotel Webster Hall, located in the Civic Center of Pittsburgh.

This annual event features reading of expert papers and an exhibit of automation equipment for the iron and steel industry.

Conference chairman is R. A. Francy of Weirton Steel Co., Weirton, W. Va., and Exhibit Committee chairman is Paul M. Hankison of Hankison Corp., Pittsburgh.

Now Hear This

BRITISH INFORMATION SERVICE.—Closed-circuit television is making its debut on British naval vessels. Picture shows captain of newest flattop H. M. S. Ark

THE NEW SIGN OF SERVICE

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This new trademark highlights Sorensen's dynamic new program of product development and service.

Back of the new trademark is the established reputation of "the world's authority on regulated power." Yet to be unveiled is a whole new concept of design, even better product performance and service convenience for every user of Sorensen's wide variety of equipment.

Selected sales and service representatives — functioning as an integral part of the Sorensen team — can place at your disposal the complete design and production facilities of Sorensen . . . yet they are local specialists in your particular area. Sorensen's Los Angeles warehouse facilities mean improved deliveries for West Coast customers.

Be sure you get *all* of the information available on any regulated power application. Make it a rule to check *first* with your local representative of Sorensen . . . "the world's authority on regulated power."

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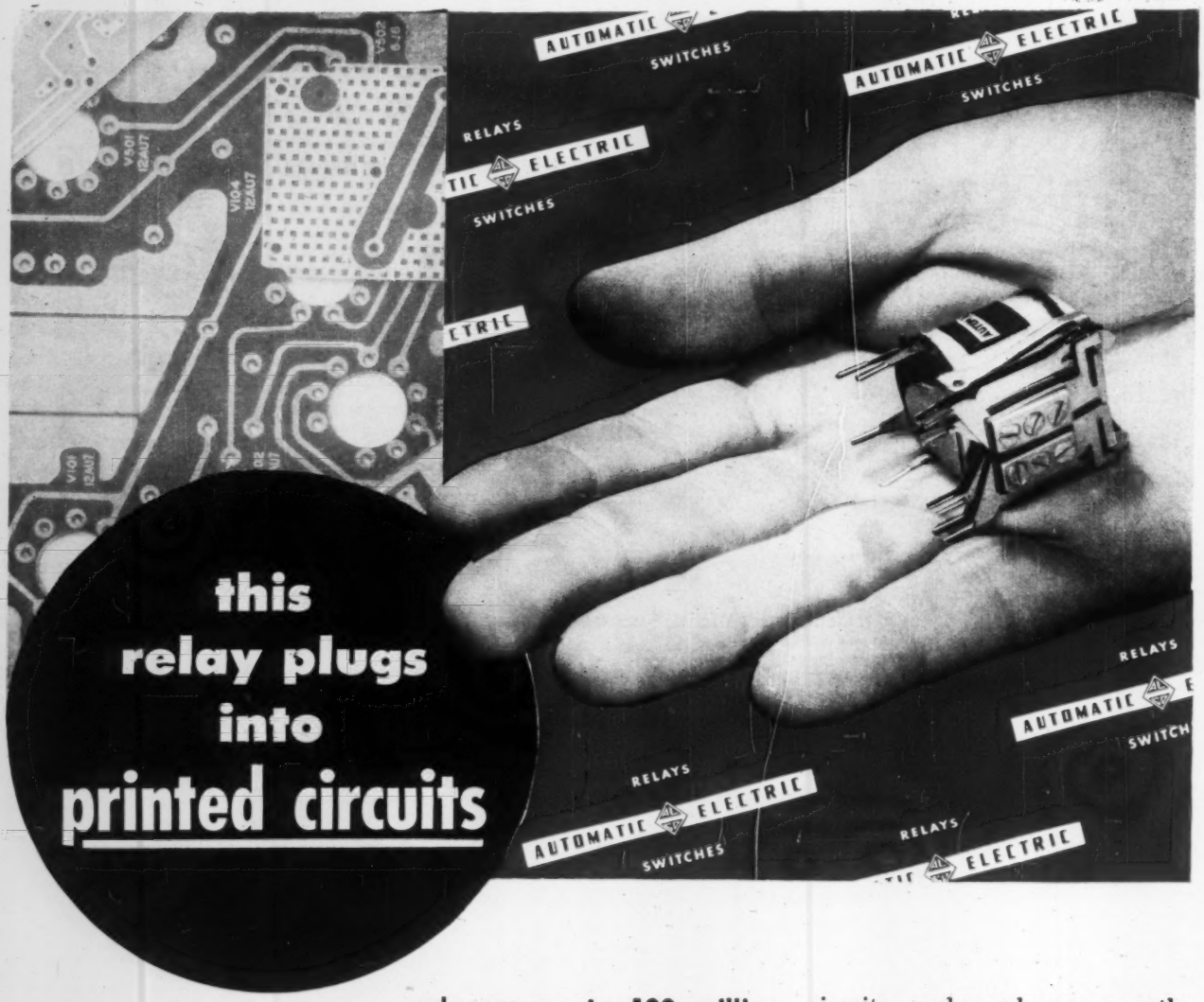
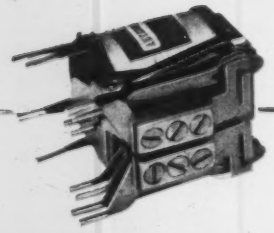


. . . and runs up to 120 million operations without attention.



HELPFUL INFORMATION FOR THE TECHNICALLY MINDED . . .

Dimensions: Length, 1¾"; height, 1⅝" to 1¾" (depending upon the number of contact springs); width, 1".

Operating Voltage: Up to 175 volts, dc, only.

Contact Spring Capacity: Maximum of 9 springs per pile-up.

Springs: Can be made of phosphor-bronze, "Bronco" metal, or other special purpose materials, as required.

A new stainless-steel armature bearing pin, a new sintered metal yoke, a new lubricating system for the armature—these features add up to 10 times the life of former relays. Automatic Electric Printed-Circuit Relays meet today's needs in automation, in computers, in any applications requiring utmost dependability.

Specially designed plug-in terminals are an integral part of the coil and of the contact springs. They make firm, tight, high conductivity connections with printed circuits—and may be permanently secured by using any recognized soldering technique.

Besides these features, you get efficient magnetic design, permanently welded contacts, "stay-put" contact springs and many other advantages found in all Automatic Electric relays. Save parts, assembly and wiring time by using printed circuits—and Automatic Electric Printed-Circuit Relays. For complete details, *write:* Automatic Electric Sales Corporation, 1033 West Van Buren Street (HAymarket 1-4300), Chicago 7, Illinois. *In Canada:* Automatic Electric Sales (Canada) Ltd., Toronto. *Offices in principal cities.*

RELAYS **SWITCHES**

AUTOMATIC ELECTRIC

ORIGINATORS OF THE AUTOMATIC DIAL TELEPHONE

CHICAGO

For more information circle **15** on inquiry card.

Royal giving orders; entertainment will also come over the TV as it used to come over the loudspeaker. The Ark Royal, designed for the atomic age, can be run by remote control with the crew in sheltered compartments.

EECO Pioneers Public Education

LOS ANGELES, CALIF.—Everybody's talking about the shortage of electronic engineers and finally something is being done about it; Electronic Engineering Company of Los Angeles is sponsoring a weekly television program in popular electronics.

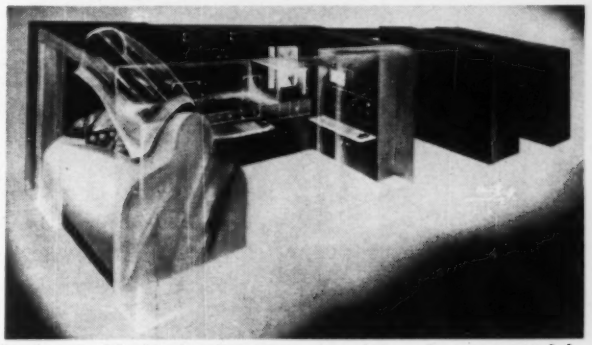
Martin L. Klein

Each week, Dr. Martin L. Klein of the Los Angeles City School system, instructor in electronics at Pierce College, shows what's going on in the field of electronics. The purpose of the program is to interest young people in the wonderful world of electronics. Every week Dr. Klein explains and demonstrates a complex piece of electronic equipment—computing machines, automation systems, high fidelity sets, etc. During the second half of the thirty-minute program, seen on KCOP, a regular commercial station in Los Angeles, Klein and Aram Solomonian actually show the audience how to assemble simple circuits. At the end of the program, they demonstrate that these circuits actually work. A local distributor carries the parts in stock for interested viewers.

This is one of the first attempts in commercial television to bring a genuinely technical subject down to the popular level and the program is being watched with keen interest by people in the television industry as a pattern for things to come.

First Supersonic Flight Simulator Demonstrated

FALLS CHURCH, VIRGINIA—The first supersonic Flight Simulator (F-100A), made by Melpar, Inc., Falls Church, Virginia, a wholly-owned subsidiary of West-



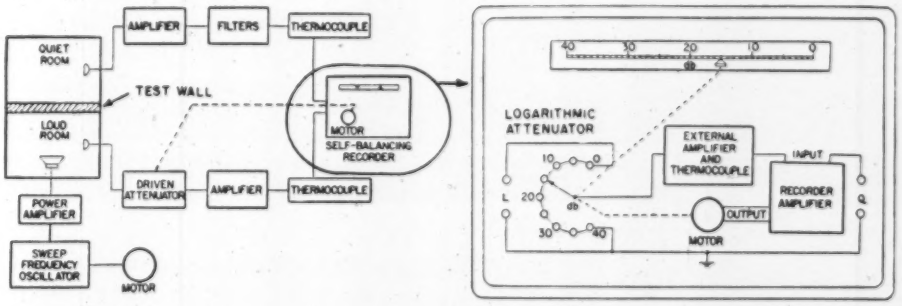
inghouse Air Brake Company has been demonstrated by the Air Force. The F-100A Flight Simulator consists of seven major assemblies and five electronic computer racks. The basic principles employed are simple. Since most conditions of flight of an aircraft are described by means of equations involving algebraic additions, multiplication, division, and integration, the simulator can set up and solve a variety of conditions identical to those encountered in actual flight. Five computer cabinets containing 80 pull-out drawers, constitute the "brain center" of the MB-3.

Think

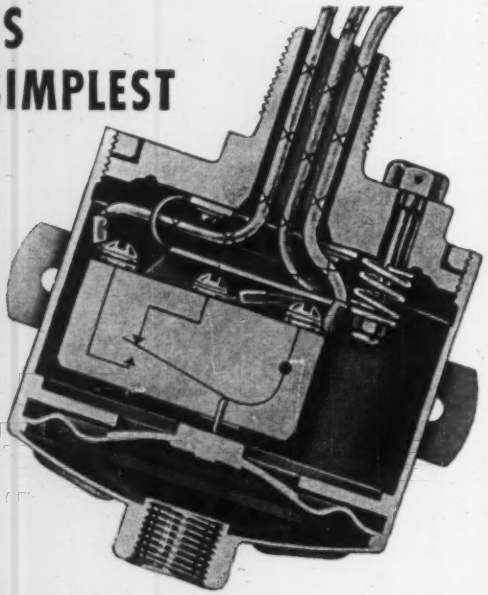
PHILADELPHIA, PA.—Engineers from Minneapolis-Honeywell's Industrial Division are attending sessions in creative engineering. For six weeks (during classes) the engineers are putting aside slide rules and electronic formulas and practicing the art of plain thinking—on general problems or specific engineering ones. The emphasis is on unrestricted, non-conformist thinking, says Steve Higgins, director of the program sponsored by the firm's research division.

Continuous Recording of Sound Transmission Loss

WASHINGTON, D. C.—Acoustical properties of building materials are valuable data to architects designing modern buildings. In new NBS test setup, Sound Transmission Loss (STL) of walls, floors and other structures is continuously recorded by conventional strip chart potentiometer modified to show decibel difference between sound levels in two rooms separated by a test wall. Microphone voltages from both rooms are fed separately into recorder. Signal from loud room is attenuated to match signal from quiet room. Note modification of con-



HERE'S THE SIMPLEST



DIAPHRAGM PRESSURE SWITCH

WE BUILD IN	WE DON'T USE
EXTREME ACCURACY This switch is guaranteed to repeat within + or − 1% of its original setting during its operating life.	**LINKAGES & BEARINGS** which, as they wear, make the setting of the pressure switch drift.
OPERATION IN ANY POSITION which saves the installation costs encountered in mounting a switch that uses liquid switching elements.	**LIQUID SWITCHING ELEMENTS** which make the switch difficult to mount and very critical to vibration.
IMMUNITY TO VIBRATION you can mount the switch directly on your vibrating or moving equipment.	**ACCORDION DIAPHRAGMS** which make the pressure switch sensitive to vibration.

BARKSDALE VALVES

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5125 Alcoa Avenue, Los Angeles 58, California

Send operating data and specifications bulletins 420-27

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COMPANY _____

ADDRESS _____

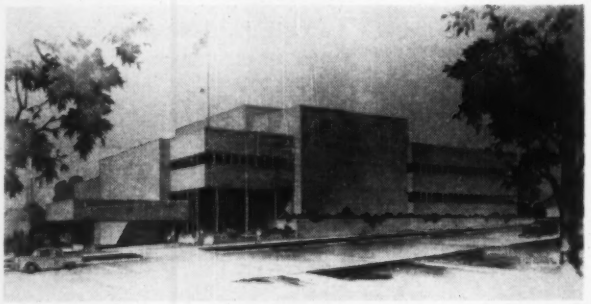
CITY _____ ZONE _____ STATE _____

For more information circle **16** on inquiry card.

ventional recorder; a logarithmic attenuator takes the place of the linear slide wire, and the standard cell is replaced by one of the two incoming signals, which are thereby compared.

New Fisher Governor Research Center

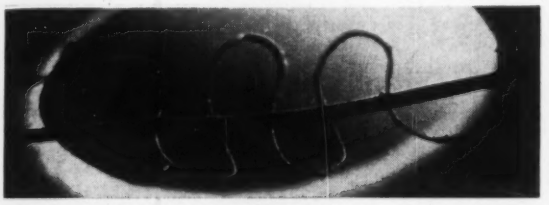
MARSHALLTOWN, IOWA.—Fisher Governor Company, Marshalltown, has moved into its recently completed research and engineering center. The new three-



story brick structure has 100,000 square feet of space and is completely air-conditioned. It covers approximately half of a square block and about 200 of Fisher's 1250 employees are assigned to the building.

Proverbial Hair-splitting Obsoleted by GE Activity

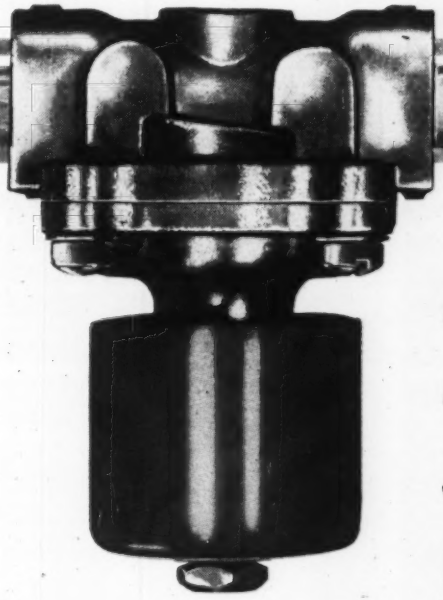
SCHENECTADY, N. Y.—To show the precision of a one-mil (0.001-inch) drill, one of the world's tiniest, General Electric instrument makers not only split a hu-



man hair but also threaded one-thousandth-inch wire through a strand of hair (shown) and a strand of nylon stocking, which is thinner than hair. The microscopic drill, too small to be seen by the naked eye, is used in GE's General Engineering Laboratory to make similar holes in X-ray apertures, leak orifices and tiny fuel nozzles.

Turbine Test Center

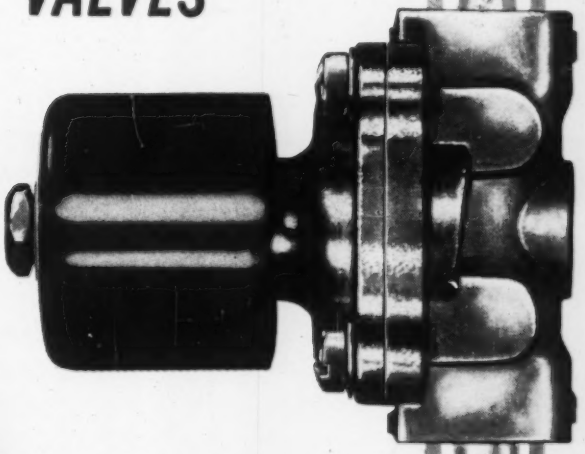
WEST TRENTON, N. J.—The Navy's new turbojet engines will soon be put through their paces in a modern, $41-million turbine test center being completed in West Trenton, N. J. The largest Naval laboratory ever built for such tests, it covers 56 acres and can simulate altitudes from zero to 65,000 feet and speed-of-sound air velocities. Here two Honeywell engineers, part of an M-H engineering team which laid out the complex electronic control system to monitor the testing operations, check out one

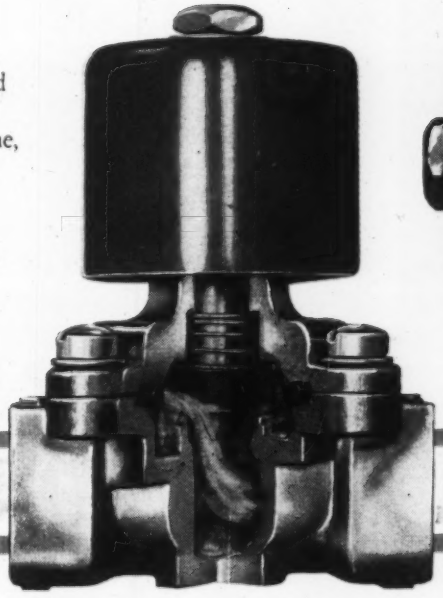


Major advance in Low Pressure SOLENOID VALVES

Extra heavy industrial type construction with tight seating assured

—for manufactured and natural gas, air, propane, butane, water, gasoline and light fuel oil —to 180°F.





Mount this new ASCO Low Pressure Solenoid Valve in *any* position without affecting its operation. For pressures up to 7 Psi, the Bulletin 8030A helps give full design flexibility to gas pilot applications on industrial ovens and furnaces — automatic dispensing and vacuum holding applications.

And ASCO combines ruggedness with simplicity by housing a single moving element — the stainless steel core and composition disc — in an extra heavy forged brass body.

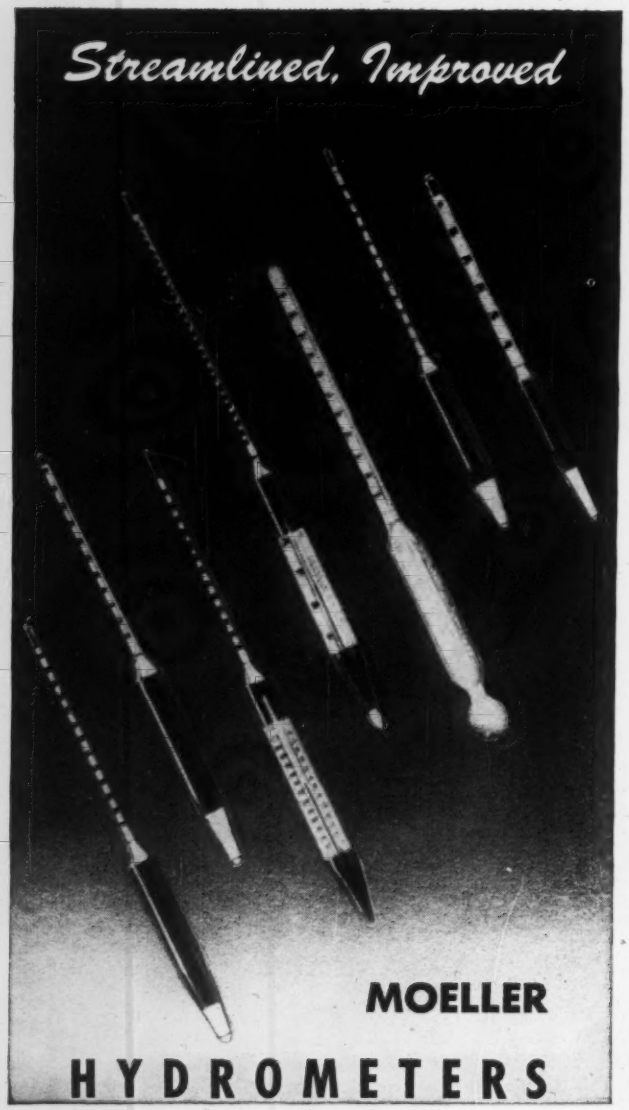
Operation is just as remarkable. Energizing the solenoid with only 10 watts provides positive opening action. Both ⅜″ and ½″ pipe sizes feature oversized ports (⅝″ orifice) for greater flow at an exceptionally low pressure drop.

There's *one* source that solves virtually any solenoid valve problem—ASCO. For full data on this new Low Pressure Solenoid Valve, write today for Application and Development Report 8030A.

ASCO

Solenoid Valves

For more information circle **17** on inquiry card.



. . . for quickly and accurately determining the density of light and heavy liquids. Made in a variety of scales, such as Brix, Twaddle, Ballings, A.P.I., etc. Specific Gravity, Baume, etc. Plain form or combined with thermometer. They are unfailingly correct.

Write for special Hydrometer Catalog today!

MOELLER INSTRUMENT COMPANY
132nd ST. and 89th AVE.
RICHMOND HILL 18, N. Y.
Representatives in Principal Cities

Gentlemen: Without obligation, please send Catalog No. 800 on Moeller Hydrometers.

NAME .....

FIRM .....

ADDRESS .....

CITY ..... ZONE ..... STATE .....

For more information circle **18** on inquiry card.

NEWS—CONTINUED

of the turbojet cells. When completed the laboratory will push more than one million cubic feet of air a minute past engines in the five test cells. To do so will require more electrical power than that used by a city of 75,000.

News Bits

GENERAL ANILINE & FILM CORP. uses a GE recording spectrophotometer to standardize dyes. Sampling time has been cut from several hours to 20 minutes.

BATELLE MEMORIAL INSTITUTE has developed a conduction-type radiation counter with a special cadmium-sulfide crystal mounted on the tip of a hypodermic needle for use in tumor locating and cancer treatment.

NORTHRUP AIRCRAFT makes use of a Baldwin-Lima-Hamilton testing machine to calibrate a fatigue load transducer for use with a 500,000-lb fatigue machine.

BECKMAN FLAME PHOTOMETER is the instrument being used at Wynn Oil Co., Azusa, Calif. to find causes of bearing failure, including lube oil analysis etc.

SYLVANIA ELECTRIC is building a new Data Processing Center in Camillus, near Syracuse, to link its 43 plants, 16 laboratories and 22 sales offices in 19 states to a "Univac" over a leased Western Union network. Production volume, sales, billing, etc., will be processed.

300-MESH PRECISION GLASS SCREEN has been developed by Corning Glass Works for use as part of a cathode ray tube.

HOBBY KITS prepared by leading industrial firms and brought out by Central Scientific Co. satisfy children's curious questions in such sciences as electronics, geology, weather, optics and medicine.

FAIRCHILD CAMERA AND INSTRUMENT CORP. has established nuclear instrumentation department to develop and manufacture radiation monitoring equipment, control rod drive mechanisms, neutron detectors, etc.

NYU'S COLLEGE OF ENGINEERING has developed instrument that accurately measures energy and frequency of ocean waves. The three-unit device (recorder, playback unit, and analyzer) will help study beach erosion, harbor protection, etc. Recording is on magnetic tape.

ACOUSTICAL METHOD for locating kidney stones and other foreign matter in the body is made possible by small transducers mounted on forceps or other surgical instruments.

household

detergent

goes to cans...

exact measure assured with General Electric

Level of fill became a problem when B. T. Babbitt, Inc., switched its household detergent, GLIM, from bottles to cans. In their own words, "The Hytafill was the only answer to our problem, and we are now assured of a desired fill in each can."

IF you package liquids or free-flowing solids in opaque containers, you need HYTAFILL. Unit inspects every container that passes along the line for both over and under fill . . . is capable of checking up to 900 containers a minute.

Easy-to-install HYTAFILL is compact . . . readily adaptable to your existing conveyor lines. It requires no special care—sealed tube head and detector can both be washed with steam or hot water. Control panel may be positioned anywhere within 50 ft of the conveyor line.

For full details on this modern quality control unit call your nearest G-E X-Ray representative . . . or write X-Ray Department, General Electric Company, Milwaukee 1, Wisconsin, requesting Pub. BL124.

Progress Is Our Most Important Product

GENERAL ELECTRIC

MANUFACTURERS OF THE ONLY COMPLETE X-RAY LINE

For more information circle **19** on inquiry card.

MEASURE-COMPARE-CORRECT with a SELECTROL in the PACKAGING LINE

. . . checks every package, weighs without stopping package flow

. . . rejects over-weights and under-weights into separate groups

. . . charts average and range of weights for statistical control of filling operation

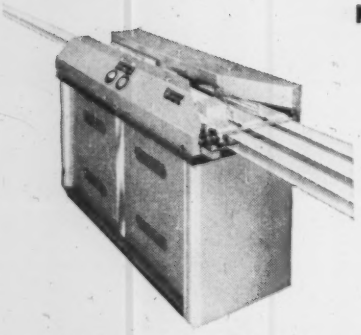
. . . with electronic controls, adjusts filling machines in closed-loop operation

SELECTROL is a time-proven production machine backed by more than 40 years of experience in industrial weighing, and is in use today on hundreds of production lines both for checkweighing and inspection by weight.

Write for details on how SELECTROL can eliminate the inaccuracies of spot checking, save time and products.

SELECTROL

MODEL 1200



Fits into any production line. Available with or without statistical control equipment. Provides accurate weight checks at speeds up to 100 units per minute.

Sales and Service Coast to Coast

Exact Weight Scales

Better quality control

Better cost control

THE EXACT WEIGHT SCALE COMPANY

951 W. Fifth Avenue, Columbus 8, Ohio

In Canada: P. O. Box 179, Station S, Toronto 18, Ont.

For more information circle **20** on inquiry card.

NEWS—CONTINUED

Data on **LOW TEMPERATURE TEST CHAMBER** facilities available in this country have been compiled by the Corps of Engineers Research and Development Laboratories, Fort Belvoir, Virginia.

YEWKUS is in airmen's lingo an automatic aerial reconnaissance system of several cameras complete with electronic "brain." Bill Jack Scientific Instrument Co., Solena Beach, Calif. manufactures it for the U.S. Air Force, saving weight with its 400 lb. over its human counterpart since no ejection seats, oxygen and pressurizing system is required.

STRATOSPHERIC FIELD STRENGTH is now being measured by sending huge plastic balloons to 100 thousand feet altitude. Philadelphia's Industrial Division of Minneapolis-Honeywell endeavors to better its famous co-citizen's Ben Franklin's experiments by supplying an instrument capable of measuring currents as low as 1/1000 million millionth of an amp.

JET FUEL is subjected to rigid temperature tests from $-67°F$ to $+200°F$, by a unit recently furnished and installed by American Research Corp., Bristol, Conn. at United Aircraft's Hamilton Standard Division, Windsol Locks. Another unit tests defrosting of evaporators under simulated severe temperature changes ranging from $+100°$ to $-67°F$.

GAMMA RAY AND NEUTRON measurements in oil wells are now shielded from interference by radiant heat, radioactivity and stray electricity by simple Type 304 stainless tubing not heavier than 0.018" discloses Superior Tube Co., Morristown, Pa.

LEHIGH UNIVERSITY'S new Fritz Laboratory can boast the largest universal testing machine in the world. Baldwin-Lima-Hamilton built the 5,000,000-lb-capacity instrument for measuring tensional, and compressional loads with ½% accuracy. Screws through which loads are applied have length of 62 ft.; diameter—16 inches; weight—45,000 lb. It takes a 75-hp motor to position the crossheads when preparing a test.

RADIOISOTOPES produced by cyclotrons will be marketed for the first time by a private company. Nuclear Science & Engineering Corp., Pittsburgh, a subsidiary of Norden-Ketay Corp. is the first company to avail itself of the existing cyclotrons to start such a program since the AEC has discontinued its program of sole supplier for industrial and medical uses in the U.S.

JONES & LAUGHLIN STEEL CORP. recently put X-ray fluorescence to use on its electrolytic tinning line in the Aliquippa, Pa. Works. The new gage perfected by J&L can measure tin coating thicknesses to within 6/10,000,000 of an inch.

FREQUENCY RESPONSE FOR PROCESS CONTROL was the topic of a symposium held by Taylor Instrument Companies. Two dozen experts discussed and shared their practical experience for their mutual benefit to which the sponsor contributed a 660-page test book.

ARTHRITIS THERAPY utilizes a new electronic "brain" developed by Minneapolis-Honeywell to control temperature in a mobile applicator to within one-quarter of a degree. The application is a new product of Hill Laboratories, Frazer, Pa.

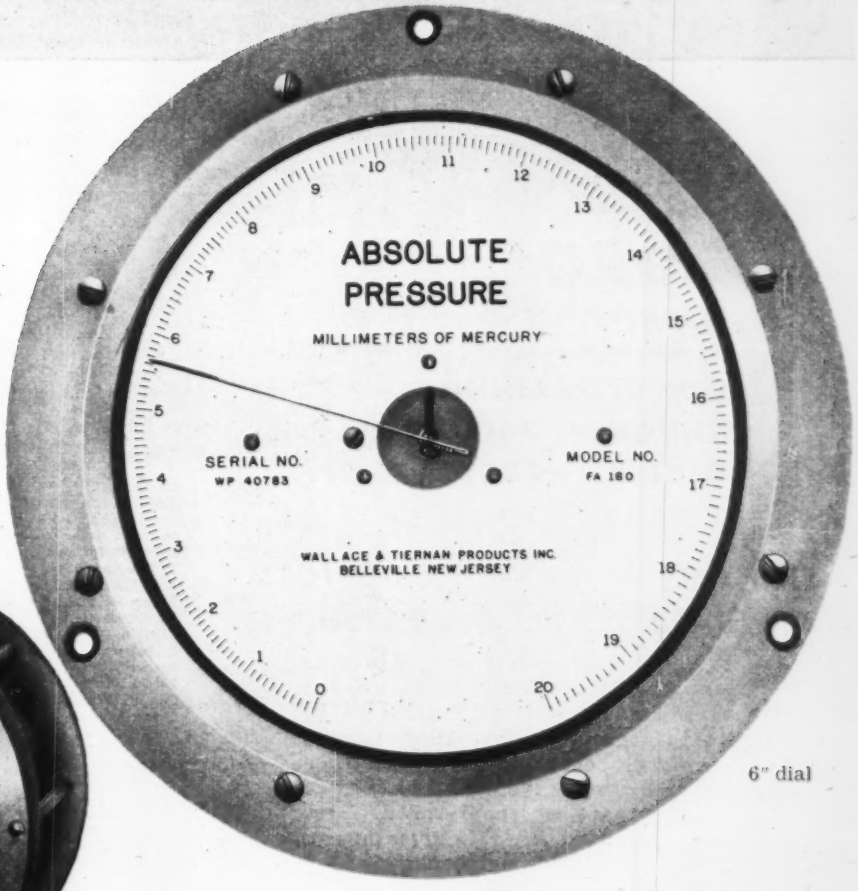
HIGH-SPEED INSPECTION of parts up to 1" x 1" x 2" inside or outside dimensions is performed by an automatic gaging device marketed in the U.S. by Pratt & Whitney as Sigmatic Machine Model A301. Manufactured by Sigma Instrument Co. of Letchworth, England it can simultaneously inspect 10 dimensions to within

ABSOLUTE PRESSURE INDICATOR

. . . FOR DEEP VACUUM WORK

Measures *pressure*
directly from
ZERO ABSOLUTE
to atmospheric

. . . swiftly and precisely



6" dial

2¾" dial

TYPE FA-160

Used as a pressure indicator in any system employing a vacuum.

- All readings are relative to ZERO ABSOLUTE.
- Dial *reads directly.*
- Accurate to 1 part in 300 over full scale.
- Sensitive to 1 part in 500 in *all* ranges.
- No auxiliary indicator or corrections for ambient pressure changes required.
- Protected against sudden pressure surges.
- Ranges:

0— 50mm Hg.	0—410mm Hg.
0—100mm Hg.	390—800mm Hg.
0—200mm Hg.	0—800mm Hg.

- Dial Sizes: All ranges in either 2¾" or 6" dia.

For additional information on W&T Absolute Pressure Indicators, write today for Publication No. TP-28-A.

WALLACE & TIERNAN
INCORPORATED
PRECISION INSTRUMENTS AND ELECTRICAL MECHANISMS
25 MAIN ST. BELLEVILLE 9, N. J.
In Canada: Wallace & Tiernan, Ltd., Toronto

A-102

For more information circle **21** on inquiry card.

BORG MICRODIAL

DIRECT READING THROUGH 3600° TO A DIGITAL ACCURACY OF 1 PART IN 1000.

FITS ANY MULTI-TURN DEVICE HAND OR SERVO OPERATED

The new direct reading Borg Microdial Model 1301 practically eliminates human error because it was designed for forced fast reading. Laboratory, production and processing controls become more accurate when clear, sharp, figures on the specially designed Borg Counter are observed through the focal-point window. Borg Counter figures are seen against a dull black background to provide maximum contrast for instant perception under difficult reading conditions.

The specially designed Borg Counter in the Model 1301 Borg Microdial reads from 000 to 999 to 000 in 3600 degrees of continuous rotation with no stops. Maximum recommended operating speed is 10,000 counts per minute (100 rpm).

Designed for military application, it has a built-in dust shield and clear-vision, wide-angle window for accurate reading from almost any position in front of the dial.

The Model 1301 Borg Microdial is compact. It measures only 1-3/4" in diameter and 1-5/8" in height and occupies no more panel space than the Micropot it controls.

WRITE FOR CATALOG SHEET BED-A31

BORG EQUIPMENT DIVISION
THE GEORGE W. BORG CORPORATION
JANESVILLE, WISCONSIN

For more information circle **22** on inquiry card.

0.00005", separate them by acceptability and rejection, and account for number of parts inspected and accepted.

CONTROL OF ELECTRICAL MACHINERY requiring two fingers to press two buttons simultaneously for safety reasons has been reported by Harris-Seybold Co. of Cleveland. Termed an idea so simple that it had been overlooked previously, Harris-Seybold will dedicate the patent (if granted) to the public without payment of royalty.

BELL TELEPHONE LABORATORIES has developed a machine for automatic wiring of complex electrical apparatus. Punched tape gives the instructions for solderless wrapping of six turns of solid conductor wire around rectangular terminals.

AUTOMATION, U. S. BRAND, is invading France. One of the first completely automated plants in Europe uses Select-O-Weigh equipment made by Richardson Scale Co., Clifton, N. J. Mendes-France, as French government official, spoke with high praise of American equipment when the S. S. Duquesne poultry feed plant was recently dedicated.

Stock Report

The following prices and price ranges are supplied by Bache & Co., 36 Wall Street, New York 5, New York

New York Stock Exchange:

Security	Price Range for Year Thru October 31 High	Low	As of October 31 Last
Aeroquip Corp.	17 1/2	8 1/2	12 1/4
American Chain & Cable	46 3/8	35 1/2	44
American Mach. & F.	35 7/8	23 1/4	24
American Mach. & M.	41 3/8	27 1/2	35 7/8
American Optical	53 1/4	38	39
Bell & Howell	42 1/4	30 1/2	33 1/2
Bendix Aviation	59 1/2	45	48 1/4
Bulova Watch	25 3/8	22 1/8	22 1/2
Burroughs	34 1/4	22 7/8	25
Clevite	25 3/8	20 1/2	20 7/8
Dobeckmun	38 7/8	30 1/4	32
Gamewell	39	30	30
General Inst.	13	7 5/8	7 7/8
General Prec.	71 1/2	37	37 3/8
General Time	39 3/4	33 1/2	33 1/2
Hamilton Watch	25 1/4	18 1/4	19 3/4 - 20 1/2 (1)
Int. Business Mach.	450	349	380
Minneapolis-Hon.	70	50 1/8	55 1/2
National Cash Reg.	47	33 7/8	36 1/8
Radio Corp.	55 3/8	36 3/4	42 1/4
Raytheon	25 3/4	13 7/8	15 1/8
Robertshaw-F.	33 5/8	26 1/2	27 3/8
Sangano Electric	30 3/8	25 1/2	26
Sperry Rand	29 5/8	21 1/4	21 1/4
Square D	52	40 1/2	46
L. S. Starrett	50	40 3/4	43 1/4
Sylvania Elec.	49 7/8	41	43 5/8
Telautograph	37 1/2	25 1/2	28 1/2
Texas Inst.	16 7/8	10 1/8	11 1/4
Underwood	43 1/8	33	34 5/8

(1) Bid - Ask price, no sale.

American Stock Exchange:

Security	Price Range for Year Thru September 30 High	Low	As of September 30, Last
Air Assoc.	12 3/4	7 3/4	8 1/2 - 9 (1)
American Meter	40	32	35
Beckman Inst.	26 7/8	19 3/8	24 1/2
Benrus Watch	10 7/8	9 5/8	9 5/8 - 9 3/4 (1)
Breeze Corp.	9 3/8	5 3/4	7 1/4
Consolidated Eng.	31 1/4	20	21
DuMont Labs.	17 1/8	13	13 1/4
ElectroData	17 7/8	10 3/8	13 3/4
Fairchild C. & I.	37 1/4	21	22 1/2
Int'l Resistance	12 3/8	5	8 1/2
Lear Inc.	13 3/8	7 3/8	7 1/2
Nat'l Res. Corp.	33 1/4	17 3/4	18
Neptune Meter	28 1/2	21	28 1/8
New Haven Clock	4 1/8	2 1/2	2 1/2
Norden-Ketay	19 1/2	11 1/2	11 7/8
Pneumatic Scale	31	27 1/2	27 - 28 1/2 (1)
Servomechanisms	13 3/8	8 1/4	9
Wallace & Tiernan	26 7/8	19 1/2	19 7/8
Waltham Watch	2 7/8	1 3/8	2 1/4

(1) Bid - Ask price, no sale.

Is A Control Valve Always A Control Valve?

Yes . . . but not necessarily a conventional control valve. The Conoflow EB Current Controller—a unique final control element—is an electric valve which controls *at the source* rather than in the line. This is the perfect solution for handling extremely viscous flows or when corrosion or abrasion presents a tough problem. In many services too, it offers a more economical approach to fluid control than by means of a conventional control valve.

The Cono EB Current Controller is essentially a pneumatic-electric transducer. It consists of the proved Conoflow Cylinder Conomotor and an electrical component such as a rheostat, potentiometer or autotransformer. The Cylinder, operating from a 3-15 psi air signal, produces precisely regulated rotary motion (to 360°) of the electrical component to control voltage, current, inductance, capacitance, resistance or other electrical values.

A widely used method of regulating fluid flow with an EB unit is to position a rheostat in the motor field or armature circuit as a direct function of the pneumatic signal pressure. On many applications, electronic speed changers and electric motors can be controlled from zero to full capacity, offering a resultant control range that cannot be matched by conventional control valves.

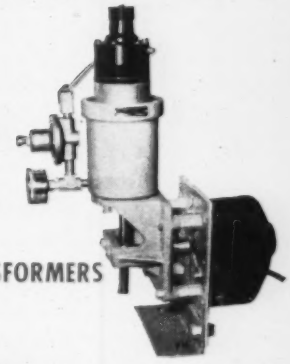
Conoflow EB Current Controllers are available in over 200 combinations of electrical components to handle a wide variety of applications. A few are suggested here:

Constant Pressure	Constant Temperature
Proportional Flow	Boiler Feed Water Control
Liquid Level	Rewind Control
Machine Tool Speed	Constant Flow
Conveyor Control	Stoker Feed Control
Heat Treating	Humidity Control

The Conoflow EB Current Controller provides automatic feedback control with these electronic speed changers:

Louis Allis—*Select-A-Spede*	Reliance—*V.S. Drive*
Brown-Brockmeyer—*Dial-A-Speed*	Servo-Tek Products—*Servo-Tek*
General Electric—*Thy-Mo-Trol*	Weltronic—*Vara-Speed*
Master Electric—*Speedranger*	Westinghouse—*Mot-O-Trol*

WRITE TODAY FOR BULLETIN EB-1. Tell us something of your process control problem. Chances are we can suggest from direct experience an installation that would be profitable to you. No obligation, of course.



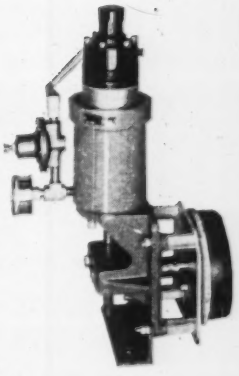
General Radio (Variac)

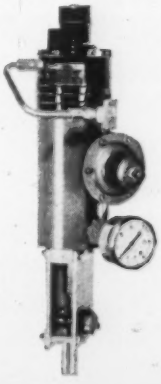
AUTOTRANSFORMERS

Superior Electric (Powerstat)

RHEOSTATS

Cutler Hammer
General Electric
Ohmite
Ward Leonard
Westinghouse





POTENTIOMETERS

Allen-Bradley
Clarostat
Fairchild
Helipot
Mallory

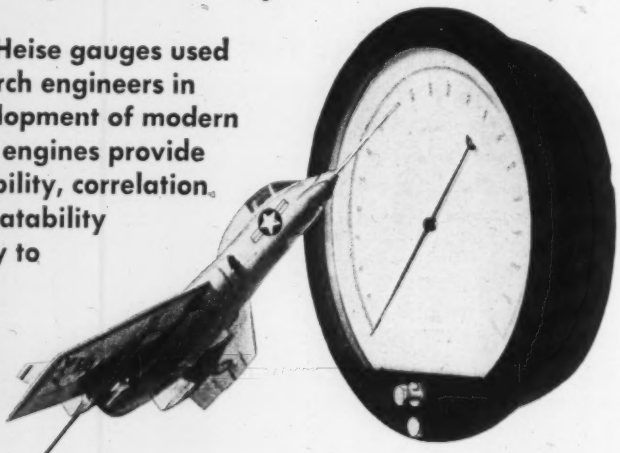
CONOFLOW CORPORATION
FOREMOST MANUFACTURERS OF FINAL CONTROL ELEMENTS
2100 ARCH STREET, PHILADELPHIA 3, PA.

Cono-Controls®

HEISE GAUGES

Conquest of the Sky

Heise gauges used by research engineers in the development of modern turbo-jet engines provide the reliability, correlation, and repeatability necessary to scientific progress.



Actual operating conditions are reproduced in the Cox Test Stand built by Commercial Research Laboratories to test for optimum efficiency of jet fuel nozzles.

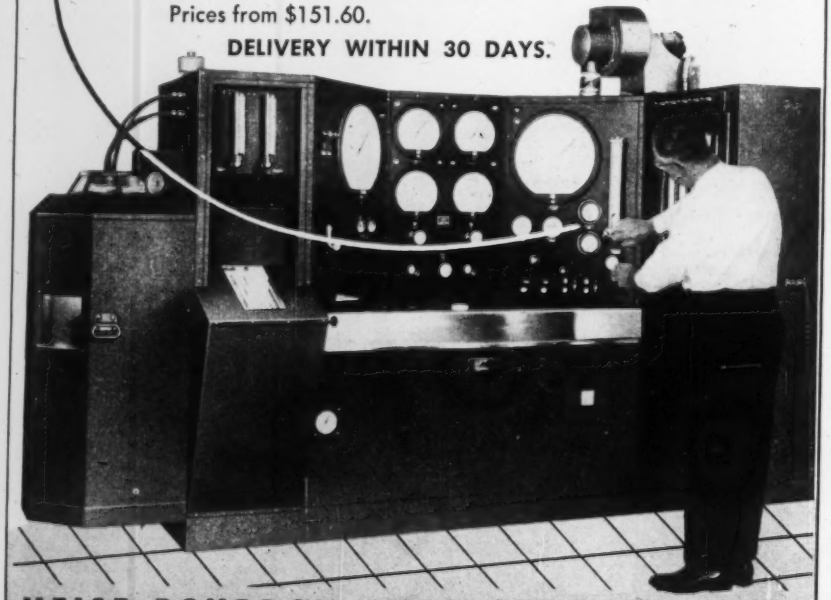
The six Heise gauges incorporated in the test stand feature in the vital and exacting performance which this instrument must accomplish.

Higher air speeds, rates of climb and economic fuel consumption, factors which every day reach and surpass new levels of efficiency, are made possible by the continuing efforts of research men equipped with today's most accurate instruments.

Pressure Ranges 15 to 20,000 P.S.I. Dial Sizes 8½"-12"-16"

Prices from $151.60.

DELIVERY WITHIN 30 DAYS.



HEISE BOURDON TUBE COMPANY, INC.

BROOK ROAD, NEWTOWN, CONNECTICUT, U.S.A.

For more information circle **24** on inquiry card.

Events...

January 25-27

Eleventh Annual Conference on Instrumentation for the Process Industries, sponsored by Chemical Engineering Dept., Texas A&M, will be held on campus. For information write Chemical Engineering Dept., Texas A&M, College Station, Texas.

January 26

Eighth annual college-industry conference sponsored by the American Society of Engineering Education at Marquette University, Milwaukee, Wis.

January 26-27

Fifth Annual Instrument Short Course at Los Angeles Harbor Junior College, Wilmington, Calif. For information write E. W. Kramer, Chairman, 5th Annual Short Course, Southern California Meter Assoc., 640 Fillmore St., Fillmore, Calif.

January 30-February 1

Seventh Annual Southeastern Symposium on Industrial Instrumentation will be held on the campus of the University of Florida. For information write W. C. Hackler, College of Engineering, Gainsville, Fla.

February 15-17

Third Conference on High-Speed Computers will be held on campus, Louisiana State University, Baton Rouge, La. For information write J. W. Brouillette, General Extension Div., Louisiana State U., Baton Rouge 3, Louisiana.

February 16-17

IRE-AIEE Conference on Transistor Circuits will be held at the Irvine Auditorium and the University Museum Auditorium, 34th & Spruce Sts., University of Pennsylvania, Philadelphia, Penna. For information write Joseph D. Chapline, Research Division, Philco Corp., Tioga & "C" Sts., Philadelphia 34, Penna.

March 18-24

Consecutive Meetings and Co-Exhibit of American Congress on Surveying and Mapping and the American Society of Photogrammetry, Shoreham Hotel, Washington, D. C. For information write ACSM-ASP, Box 470, Washington 4, D. C.

March 19-29

Ninth annual short course in Quality Control by Statistical Methods, College of Engineering, University of Illinois. For further information write to Professor John A. Henry, Mechanical Engineering Laboratory, University of Illinois, Urbana, Illinois.

April 5-6

Special Technical Conference on Magnetic Amplifiers, cosponsored by

AIEE Committee on Magnetic Amplifiers, IRE Professional Group on Industrial Electronics and ISA Central New York Sec., Hotel Syracuse, Syracuse, N. Y. For information write Charles F. Spitzer, General Electric Co., Bldg. 3, Electronics Park, Syracuse, N. Y.

April 26-27

Technical Conference on Electrical Recording and Controlling Instruments sponsored by AIEE, ASME and ISA cooperating, to be held at the Hotel Bradford, Boston, Mass. For information contact E. T. Davis, Leeds & Northrup Co., 4901 Stenton Ave., Philadelphia, Pa.

May 14-19

International Colloquim on Spectroscopy, 6th annual meeting to be held at Amsterdam, Netherlands. Persons wishing to attend or contribute should correspond with the Secretary, Colloquim Spectroscopicum Internationale, Laboratorium voor Analytische Chemie, 125 Nieuwe Achtergracht, Amsterdam-C4, Netherlands.

April 8-13

129th National Meeting of the American Chemical Society will be held in Dallas, Texas.

April 13-14

Tenth Annual Spring Television Conference sponsored by the Cincinnati Section of the Institute of Radio Engineers will be held at the Engineering Society of Cincinnati Building, 1349 E. McMillan St., Cincinnati, Ohio. For information write Reuben Nathan, Crosley Div., Avco Mfg. Corp., Glendale-Milford Rd., Evendale, Ohio.

April 25

Symposium on "Control Systems Engineering—Electronic Controls In Industry" sponsored by the Wilmington Section, ISA. For information contact W. G. Schmick, Minneapolis-Honeywell Regulator Co., Orange St., Wilmington, Del.

May 14-17

The Physical Society 40th Exhibition of Scientific Instruments and Apparatus, Royal Horticultural Society's Halls at Westminster. For information write Exhibition Secretary, 1, Lowther Gardens, Prince Consort Rd., London, S.W. 7, England.

November 26-30

Third International Automation Exposition, New York Trade Show Building, 500 8th Ave., New York, N. Y. For information write Richard Rimbach Associates, 845 Ridge Ave., Pittsburgh 12, Penna.

HOKUM ON PREAMPLIFICATION

Way out in our back room we have a section devoted to Engineering. One purpose of this group is to see to it that our relays work in the job for which our customers purchased them. Our man Waldo Hokum, one of the members of this group, has for years been untangling circuit problems that have had an unflattering effect on our relays and during this time he has been able to segregate many problems and assemble them in definite categories.

One category soon became so large that we had to take more floor space to make room for it — that was, and is, how to get conventional relay response to low impedance D.C. signals of the order of 0.1 to 100 microwatts. Many relay uses call for amplifying these signals so that they will be strong enough to activate even our most sensitive relays. This is especially important to people who work with photocells, thermocouples and the like.

Waldo stuck with this one through various stages of vacuum tubes, transistors, toroidal coil magnetic amplifiers and such, but never was really happy about his progress. There was always something like high cost, fragility or instability to cast a dark shadow on his otherwise blissful existence. It wasn't until he designed and made his own magnetic amplifier that he began to see the sunshine again.

What he came up with was a magnetic amplifier which, among other things, included conventional bobbin wound coils rather than toroids. This made our directors happy, because even they know that the manufacturing costs are *much* less with bobbins, and, what is more important, it made Waldo happy. He discovered that his new gismo, together with the circuitry that he developed to go with it, had some rather interesting specs, generally as follows:

MAGNETIC AMPLIFIER RELAY SERIES 8000*

Sensitivity:	0.1 to 100 microwatts	
Nature of signal:	D. C. from 0.1 to 30,000 ohms	
Relay response:	Polarity sensitive — snap action	
Contact form:	(1) 3-position, center neutral (2) SPDT	
Contact rating:	1-5 amperes at 28VDC or 115VAC	
Speed of response:	30 to 300 milliseconds depending on overdrive and L/R of input circuit	
Environment:	Standard	Available
Vibration	5 g. to 30 cps.	10 g. to 500 cps.
Temperature	0° to 50°C	-55° to 125°C
Shock	10 g	100 g
Power Supply:	115V @ 60 cps.	115V @ 400 cps.

This thing is now at the point where it would be worth your time to play around with — that is if the above specs bracket your problem generally and especially if you need to monitor the conditions of bridge balance or compare the outputs of low impedance D.C. signal sources.

If such is the case, Waldo has some sample "packages" that not only include his magnetic amplifier, and a Sigma Relay (natch), but also the circuitry that makes the thing work. If you think you'd like one of these to fool with, or wish more information on this subject, we suggest you write to us, attention of our man Waldo. His name really is spelled Holcombe.

SIGMA

SIGMA INSTRUMENTS, INC.
75 Pearl St., So. Braintree, Boston 85, Mass.

For more information circle **25** on inquiry card.

New E-I Frequency Counter has *true* digital in-line read-out!

Here's the answer to your need for an accurate, easy-to-use, events-per-unit-time meter. No other counter has so many convenient features, or is so easy to read. Even the most inexperienced personnel can become proficient in its use *in just seconds!* Human error and reading ambiguities are virtually eliminated.

Important new features found on no other counter!

Easy-to-read digital in-line read-out—Gives readings in simplest possible form. Eliminates reading errors.

Constant reading during sampling—Reads out instantly at end of sampling. No lost readings. No hold adjustments. No annoying sampling changes or "dead-times."

Decimal coded contacts give simple, direct, print out. No intermediate equipment required. No "dead-time" during print out. Operates all types of printers.

Read-out may be remoted and miniaturized—If space is restricted or if used in console-type equipment, the read-out and controls may be remoted on a standard 1¾" rack panel. ½" and 1" high numerals are available.

SPECIFICATIONS—MODEL 250

In-Line Events-per-unit-time Meter and Counter.

Display: 5 in-line digits, 1" high numerals. Display held constant during sampling cycle.

Accuracy: ±1 digit

Frequency Response: 10 cycles to 100 kc

Sensitivity: 0.2 volts rms

Input Impedance: 10 megohms

Time Base: 1 second, crystal controlled. (0.1 and 10 seconds optional)

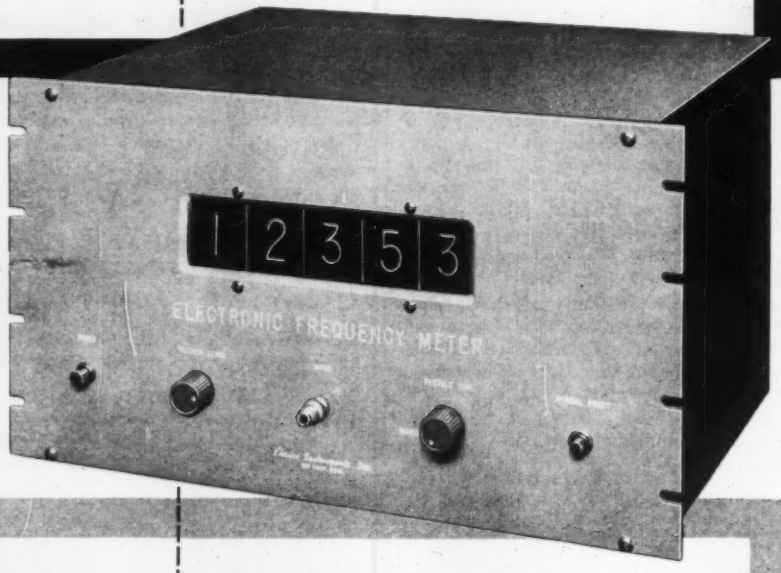
Controls: Power on-off, sensitivity, re-cycle time, manual time base, manual reset button.

Printer Operation and Remote Read-Out: Optional

Power: 115 volt, 60 cycle

Mounting: Rack or bench

Other standard models and Timers, Universal Counter-Timers available.



E-I "CLOSES THE LOOP"

Now, by adding digital, in-line frequency counters to the E-I line of digital instruments, we are able to offer complete system engineering and system solution. Your phone call or letter will start our engineers thinking about *your* problem.

Automatic, single package, precision instrumentation custom engineered to your system requirements

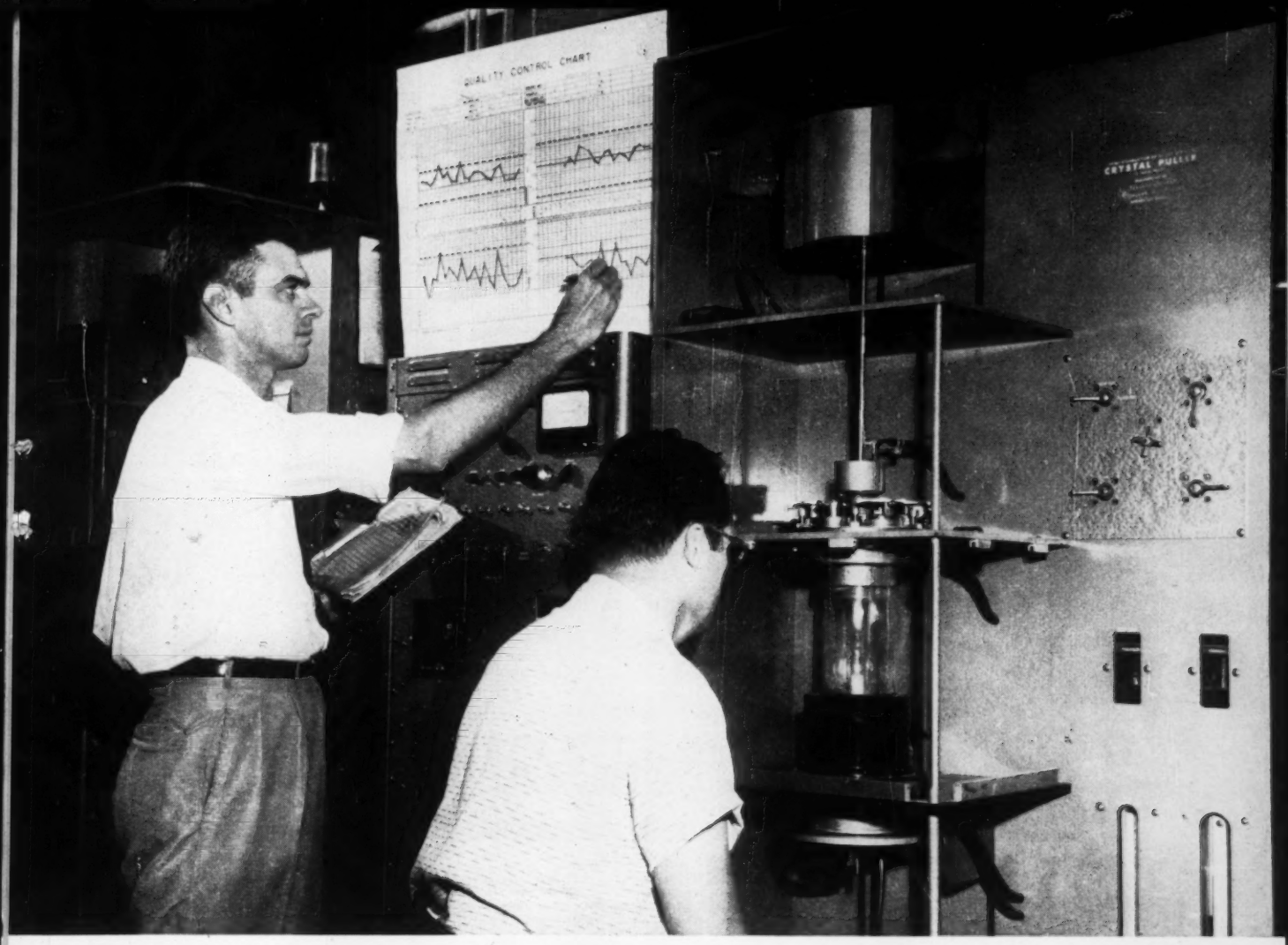
Fundamental Parameters	E-I Instruments	
DC	DC Digital Voltmeters	Automatically gives digitized data in both visual and printed form
AC	AC-DC Digital Voltmeters	
Ω	Digital Ohmmeter	
f	AC-DC-Ω Digital testers	
	Digital Frequency counters	
	X-Y Recorders	

Your E-I representative has complete information on all models and how they can be applied to your counting problems. Contact him today.

ELECTRO INSTRUMENTS INC.

3794 Rosecrans Street, San Diego 10, California

For more information circle **26** on inquiry card.



CLOSE PARAMETER CONTROL MEANS

TI transistors standardize your production circuits!

YOU CAN NOW DESIGN transistorized circuits to standard device specifications. Texas Instruments *controlled parameter* semiconductor devices fit your specific applications without additional testing and selection. Parameter tolerances are closely held and accurately described in new comprehensive design data. All TI germanium and silicon transistors are manufactured and 100 per cent tested for exacting design characteristics.

This close parameter control has enabled Texas Instruments to pace the industry in transistor development and application. Newest TI germanium devices are n-p-n high speed switching transistors. An important step toward complete transistorization of computers, these grown junction units have beta spreads of two-to-one and are 100 per cent tested for switching characteristics. TI was also first to produce silicon transistors commercially, and *only* TI manufactures germanium transistors for *all* three transistorized pocket radios now on the consumer market. For radio, general purpose, and many specific applications, Texas Instruments manufactures both p-n-p alloyed junction and n-p-n grown junction germanium types.

For your own transistorized product development, specify the exact devices you need from TI's wide range of semiconductor products — germanium and silicon; p-n-p or n-p-n types; diodes, triodes, tetrodes. Write for new descriptive data and curves that will help simplify your production problems.

TEXAS INSTRUMENTS
INCORPORATED
6000 LEMMON AVENUE DALLAS 9, TEXAS

TWENTY-FIFTH YEAR OF PLANNED GROWTH

For more information circle 27 on inquiry card.

SEND THE COUPON FOR DETAILS

Please send comprehensive data and curves describing the semiconductor products checked below:

GERMANIUM

- ☐ Radio transistors, p-n-p and n-p-n types
- ☐ High speed switching transistors
- ☐ P-N-P alloyed junction general purpose transistors
- ☐ N-P-N grown junction general purpose transistors
- ☐ Phototransistors
- ☐ Grown junction tetrodes

SILICON

- ☐ General purpose transistors
- ☐ Power transistors
- ☐ Junction diodes
- ☐ Voltage reference diodes

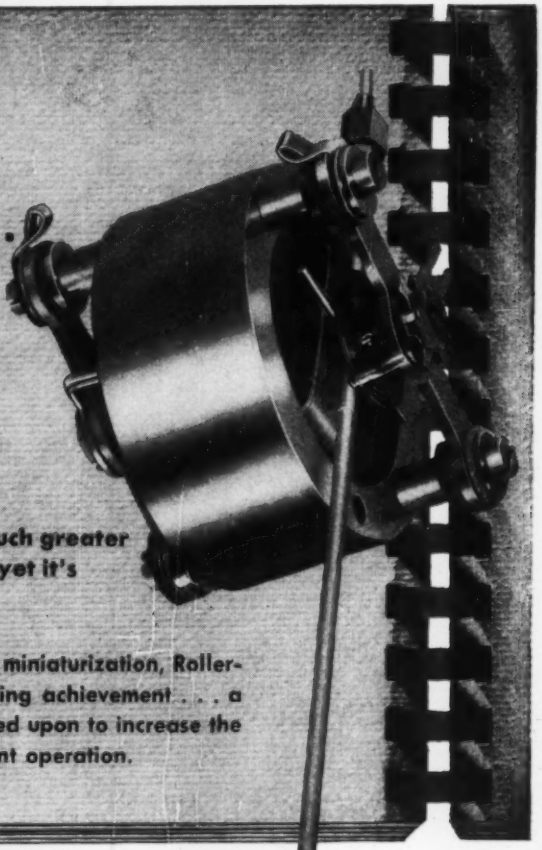
Name _____

Company _____

Address _____

_____

This
is just 1/2 the story...



the new CORE MAGNET MECHANISM

by ROLLER-SMITH

master instrument makers

. . . outperforms conventional mechanisms of much greater weight in a wide variety of applications . . . yet it's rugged and "tops" in dependability.

Combining improved efficiency and performance with miniaturization, Roller-Smith's new Core Magnet Mechanism is an outstanding achievement . . . a precision, self-shielding movement that can be counted upon to increase the prestige of your product through consistently excellent operation.

But furnishing this fine Core Magnet Mechanism is only half the Roller-Smith story!

Just as important to you is our ability to furnish the designing skill necessary to incorporate it into your own equipment. The Roller-Smith engineering staff, headed by world-renowned experts and backed by the finest in research and development facilities, will be glad to assist you in arriving at the most practical solution.

ROLLER-SMITH

Instrument Division

CORPORATION

1825 WEST MARKET STREET BETHLEHEM, PENNSYLVANIA

Precision Products Since 1908

For more information circle **28** on inquiry card.

CRESCENT ARMORED MULTITUBE *for Underground runs*

gives lowest cost with permanence for Instrument and Control Tubing

This construction of CRESCENT ARMORED MULTI-TUBE may be laid in a deep trench for long underground runs without any further protection other than that offered by its lead sheath, asphalted jute, two layers of heavy galvanized flat steel armor with an asphalt impregnated jute outer covering.

The economy of this method is obvious. Also the copper tubes are completely safe from mechanical injury, and the thick asphalted jute coverings protect the metal from moisture, corrosion, earth acids and alkalies. Under road crossings where very heavy traffic is encountered, it may be buried in concrete poured into the bottom of the trench or it may be pulled through conduit.

Up to 37—¼" O.D. copper tubes may be furnished in this and several other forms of CRESCENT ARMORED MULTITUBE, one of which should best suit your installation requirements at substantial cost savings and resulting in a better protected job.

Licensed under U.S. Patent 2,578,280.

SEND FOR BULLETIN GIVING INFORMATION AND ENGINEERING DATA

CRESCENT
INSULATED WIRE & CABLE CO.

OLDEN & TAYLOR STS., TRENTON, NEW JERSEY

For more information circle **29** on inquiry card.

IN RETURN FOR CHARACTER ...A CAREER

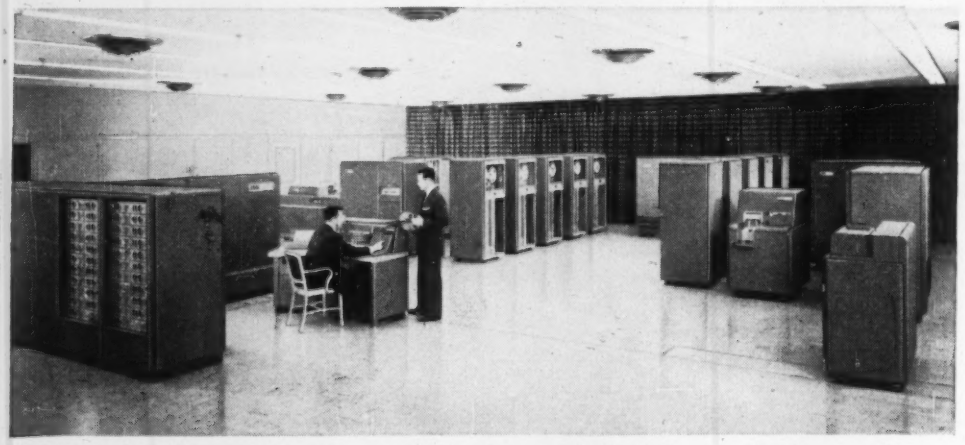
Because the finest single attribute anyone can offer is character, this, basically, is what IBM asks of its people, whatever their special aptitudes or abilities. IBM offers them in return—not just a job—but a career.

IBM field engineers and technicians, for instance, receive more than training and early responsibility; they have a chance to work with the world's largest computer, use the latest testing equipment, employ the finest computer testing techniques yet devised.

Above all, they have the satisfaction of joining the electronics industry's most advanced program, destined for long-range national importance.

You could ask for no finer future.

For further information about engineering and technician assignments available at IBM, write: Nelson O. Heyer, IBM, Room 3612, Neighborhood Rd., Kingston, N. Y.



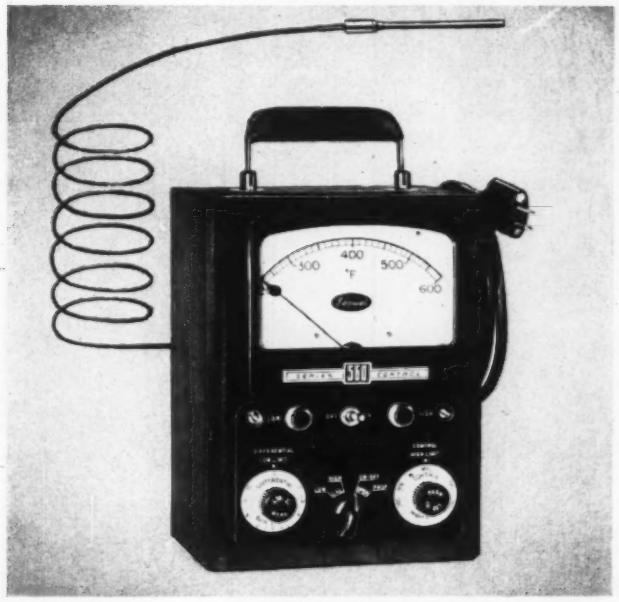
The 702 Electronic Data Processing Machine, typical of advances that have made engineering work at IBM one of the most provocative experiences in electronics.

INTERNATIONAL BUSINESS MACHINES CORPORATION

IBM ®

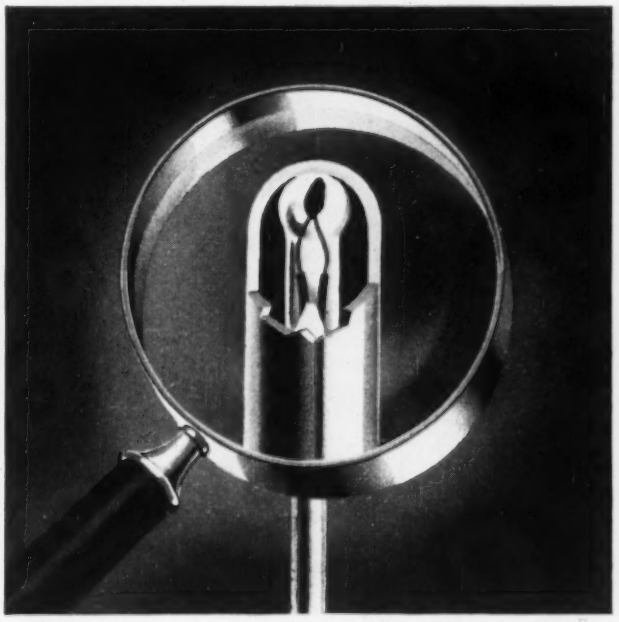
Producer of electronic data processing machines, electric typewriters, and electronic time equipment.

Which of these two instruments provides the temperature control accuracy you need?



1. IT'S ELECTRONIC! The new Series 560 applies the thermistor principle in temperature indicator controls with heretofore unattainable accuracy over a scale range of 200° to 600°F. It's the *only* instrument that provides the three major control modes — (1) on-off (2) proportional (3) adjustable differential — all at the flip of a switch. Wide range of use for general laboratory, processing, molding or packaging applications.

2. IT'S MECHANICAL! The new Series 540 indicating controller combines low cost with high accuracy over a temperature range of 100° to 700°F. Temperature changes are transmitted by a bulb and bellows to an indicator control. Instrument features on-off control . . . adjustable differential . . . ambient compensation. May be flush or surface mounted. Capacity of 15 amps at 115 volts.



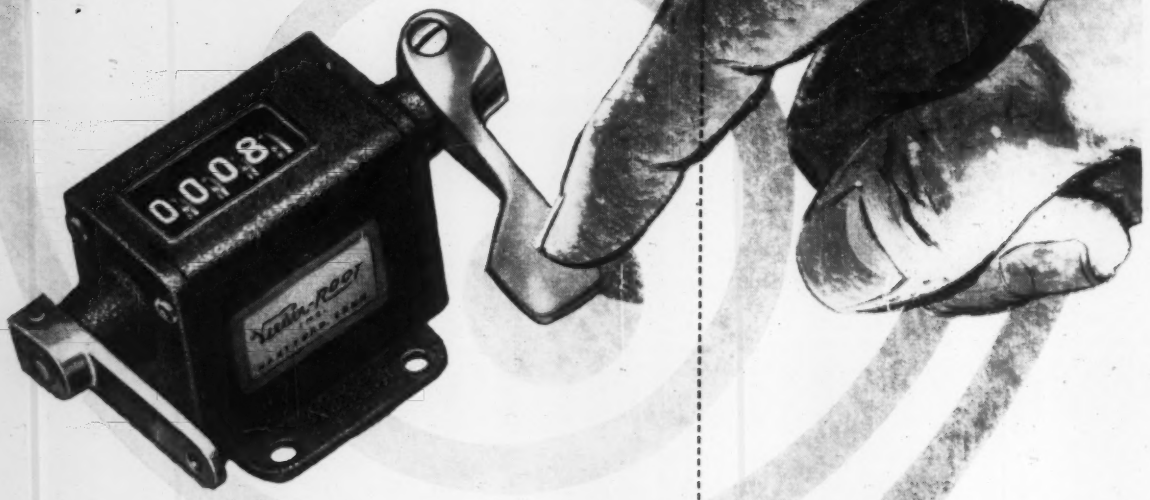
3. SIMPLICITY ITSELF is secret of Fenwal's Series 560 — accuracy, sensitivity and ruggedness. The thermistor's high resistance change permits operation with any length of lead wire up to 200 feet without affecting signal strength or accuracy. Thermistor is hermetically sealed in glass for stability; encased in stainless steel for ruggedness. No complex circuitry; maintenance is easy.

4. EASY "SET" AND "CHECK" OPERATION is a feature of Fenwal's Series 540 which is accurate to within 2% over the 100° to 700°F range, including the effects of ambient temperatures. Send for FREE NEW BULLETINS, MC122 on the Series 540, MC123 on the Series 560. Both contain full data you should have. Write to **Fenwal Incorporated, 3612 Pleasant St., Ashland, Mass.**

Fenwal Controls Temperature... *Precisely*

For more information circle **30** on inquiry card.

now.....
VEEDER-ROOT
gives you



instant "push-button" resetting

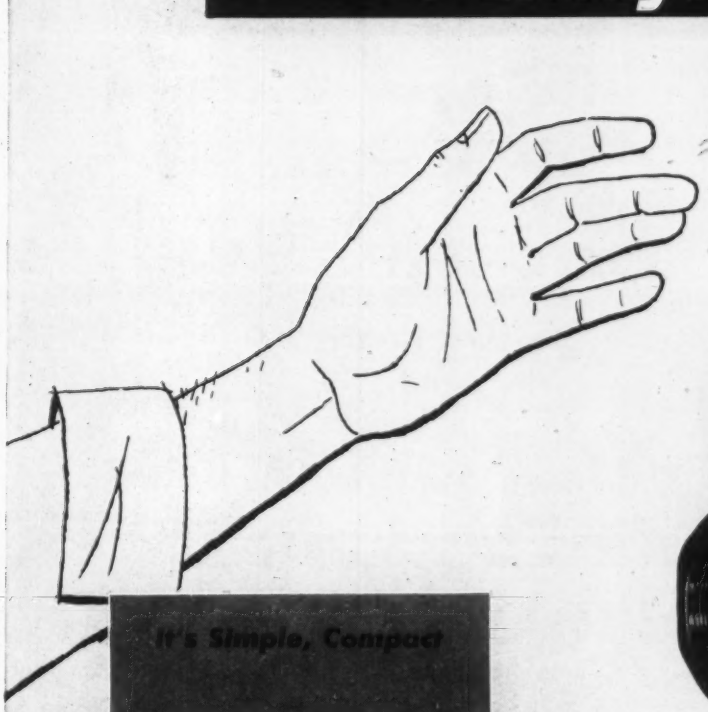
Just press the easy-acting lever on this Quick-Reset Ratchet Counter . . . *and all 4 figures reset to zero as instantly as though you used a push-button.* This saves time and speeds work on short machine runs, inspection and many other jobs. Counter is compact . . . 2.69″ long, 1.44″ high, 1.29″ wide. The 4 white-on-black figures are .166″ high. You can order it (Series 1126) from stock right now . . . just like scores of other Veeder-Root Counters for manual, mechanical and electrical operation in every field from electronics to atomics.

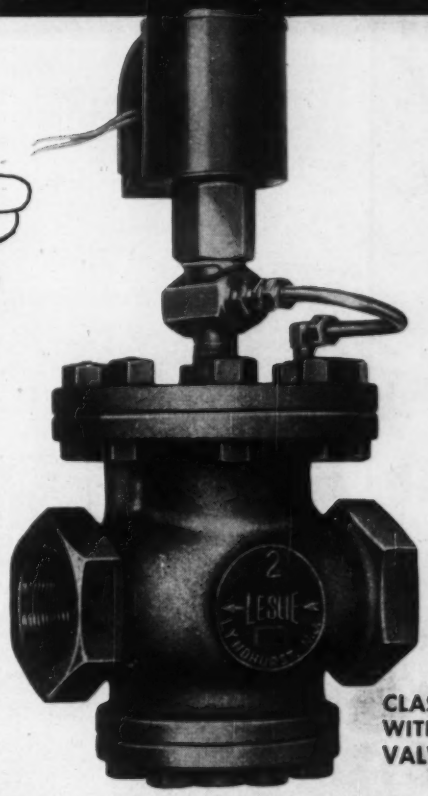
VEEDER-ROOT INCORPORATED
HARTFORD 2, CONNECTICUT
Greenville, S. C. • Chicago 6, Ill.
New York 19, N. Y. • Montreal 2, Canada
Offices and Agents in Principal Cities

EVERYONE CAN COUNT ON
VEEDER-ROOT
"THE NAME THAT COUNTS"

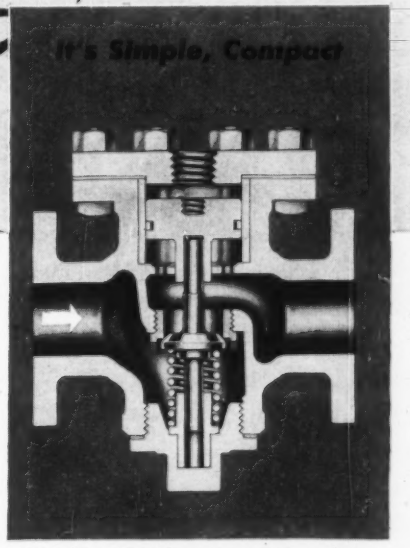
For more information circle **31** on inquiry card.

This operating valve is *always* within *reach*





CLASS LG WITH SOLENOID VALVE



Simplicity and compactness keep cost *down*, reliability *up* in this Leslie Class LP operating valve.

Make a demand — the valve obeys. It's like having a third hand and a long arm as the control for this shut-off valve is *always* within *reach*.

You can get Leslie shut-off valves equipped with an electric solenoid valve (Class LG) or you can operate them remotely (LP) with air or hydraulic relay valve. Valve opens and closes on demand of a manual or automatic signalling device (pressure switch, thermostat, etc.)

Designed for off-on service, there are units with body ratings to 1,000 psi and temperatures to 750°F. The valves give fast, tight shutoff of steam, air and non-corrosive fluids.

Ask your Leslie engineer to help you select the operating valve that's engineered to meet your service requirements. You'll find him listed under "Valves" or "Regulators" in your classified telephone directory.

Bulletin 5309 describes operating valves.
Send for it today.

TRADE LESLIE MARK

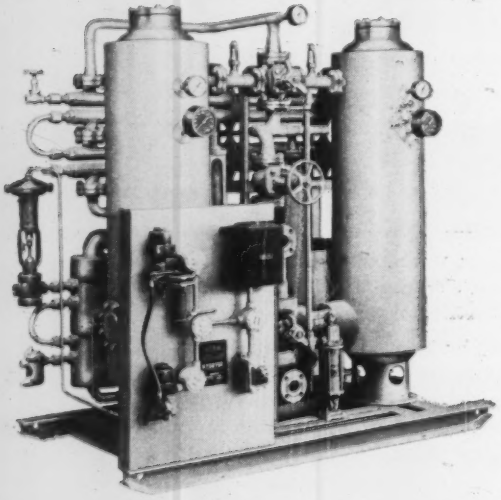
REGULATORS AND CONTROLLERS

LESLIE CO., 299 GRANT AVENUE, LYNDHURST, NEW JERSEY

CONTROLLED QUALITY MEANS QUALITY CONTROLS

For more information circle **32** on inquiry card.

AUTOMATION INSTRUMENTS MUST HAVE DRY AIR— THE PRITCHARD HYDRYER DELIVERS IT!



Precision instruments depend upon a constant source of exceptionally dry air to operate accurately. Instrument and plant shutdowns due to moisture, corrosion, icing are too expensive to be tolerated in the modern plant.

The Pritchard Hydryer®—a low-cost, packaged, dehydration unit—ends the possibility of moisture formation in instrument air.

The Hydryer removes moisture from air, carbon dioxide, synthesis gas and many other gases. It has been proved in use in the gas, chemical, petroleum, electric utility and general industries.

Exclusive design features make the Hydryer superior to any other such unit on the market today. Why don't you investigate these features?

WRITE TODAY for HYDRYER BULLETIN 16.0.081 on your company letterhead!

INDUSTRY'S PARTNER FOR PROGRESS

COOLING TOWERS
GAS & AIR TREATING EQUIPMENT

REPRESENTATIVES IN PRINCIPAL CITIES FROM COAST TO COAST

J.F. Pritchard & Co.
OF CALIFORNIA
A DIVISION OF J. F. PRITCHARD & CO.
Dept. 449 4625 Roanoke Parkway, Kansas City 12, Mo.

For more information circle **33** on inquiry card.

Constant-voltage power for thousands of measurements—

with

MALLORY Mercury Batteries

Pocket-size pH meter uses 6 Mallory RM-12R cells for power.

TO GET sustained accuracy of measurements for long periods between replacements, be sure to use Mallory Mercury Batteries in your portable instruments.

These unique batteries have a constant-voltage, constant-current discharge that eliminates a major source of drift in calibration. They do not deteriorate during long periods of storage, even under extremes of temperature and humidity. Providing high milliampere-hour capacity in small volume, they make an ideal power source for use with transistors or in any instrument in which space saving is important.

Mallory Mercury Batteries are permanently sealed . . . cannot swell or leak. Their rugged design withstands high impact and acceleration.

A wide range of capacities and voltage ratings is available. Write to Mallory for complete technical information.

Radiation detector for Civil Defense use is powered by 5 Mallory RM-12R batteries and a Mallory M-412R unit.

Parts distributors in all major cities stock Mallory standard components for your convenience.

Serving Industry with These Products:

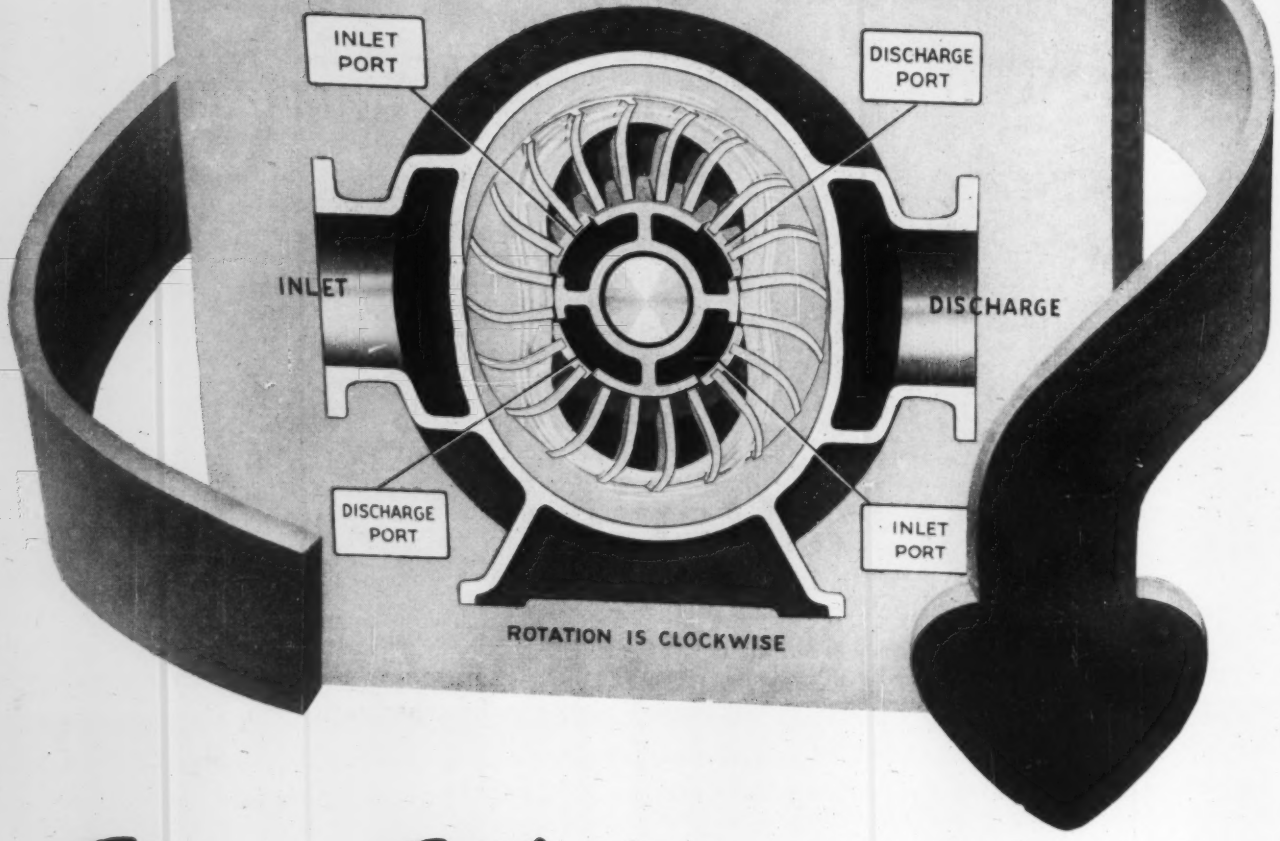
Electromechanical—Resistors • Switches • Television Tuners • Vibrators
Electrochemical—Capacitors • Rectifiers • Mercury Batteries
Metallurgical—Contacts • Special Metals and Ceramics • Welding Materials

Expect more...
Get more from

P.R. MALLORY & CO. Inc.
MALLORY
P. R. MALLORY & CO. Inc., BATTERY DIV., NORTH TARRYTOWN, N.Y.

For more information circle **34** on inquiry card.

Nash Instrument Air Compressors deliver only clean air, free from oil or dust, and without filters



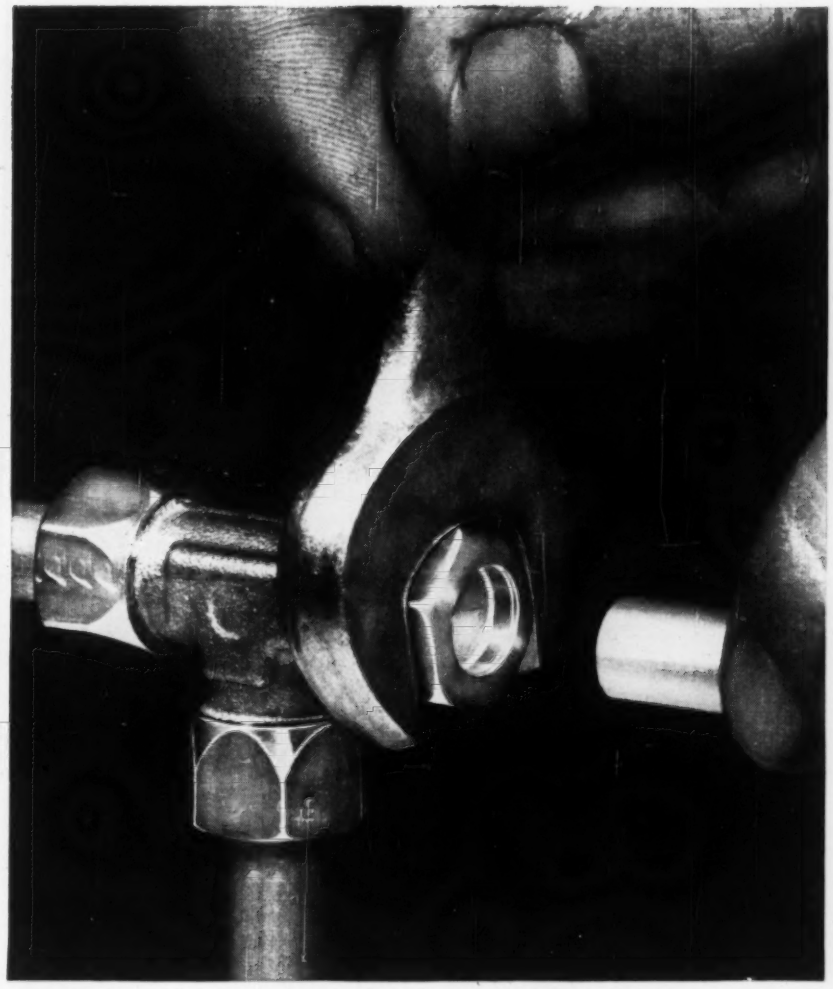
Here is Why!

You can dispense with oil filters and dust filters when you install ®Nash® Clean Air Compressors. You can save the cost of maintaining these devices. You can greatly reduce instrument maintenance costs. For the Nash employs no internal lubrication, therefore no troublesome oil is in the delivered air. Moreover, air from a Nash is thoroughly washed and cooled as it passes thru the pump. Dust in the plant atmosphere, even fly ash, is immediately removed.

®Nash® Clean Air Compressors are simple, with only one moving element. No valves, gears, pistons, sliding vanes, or other enemies of long life and constant performance complicate a Nash. No aftercoolers are needed. You will find it profitable to investigate these pumps, now.

No oil filters.
No dust filters.
No internal lubrication to contaminate air handled.
No internal wearing parts.
No valves, pistons, or vanes.
Non-pulsating pressure.
Original performance constant over a long pump life.
Low maintenance cost.

NASH ENGINEERING COMPANY
370 WILSON, SO. NORWALK, CONN.

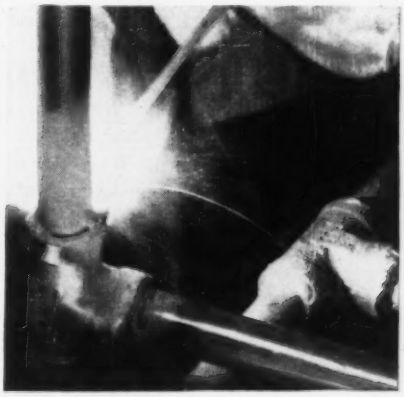


Introducing easy-to-use PARKER INTRU-LOK tube fittings for instrumentation lines of ¼" through 1" O.D.

Simply push, then tighten! Anyone can quickly install all-new, *lightweight Intru-lok* tube fittings . . . the proven Parker 3-piece flareless design. Just insert the tube, then tighten the nut with a regular wrench . . . for a leakproof, vibration-proof joint. Made of brass for copper or nylon tubing. Mail the coupon for complete details in Catalog 4324.

TUBE AND HOSE FITTINGS DIVISION
The Parker Appliance Company
17325 Euclid Ave., Cleveland 12, Ohio

For soft plastic tubing you use knurled nut and expander insert with new *Intru-lok* body. Joints can be disconnected and reassembled. Complete details in Catalog 4324. Send for it.



Weld-lok fittings, for extreme temperatures, corrosion conditions . . . machined from high-quality steel or stainless bar stock and forgings . . . for tubing ¼" through 2" O.D.

TUBE AND HOSE
FITTINGS DIVISION
Section 413-Q
The Parker Appliance Co.
17325 Euclid Avenue
Cleveland 12, Ohio

☐ Send new Parker *Intru-lok* Catalog 4324

☐ Also, *Weld-lok* Catalog 4370

Name _____ Title _____

Company _____

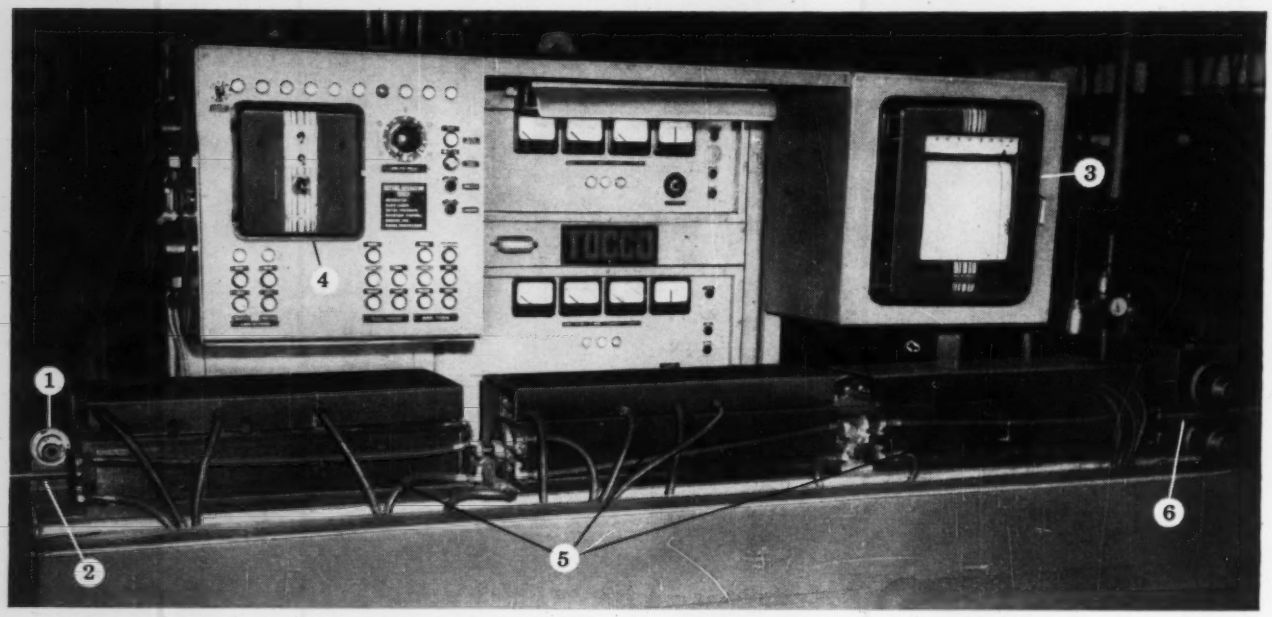
Address _____

City _____ State _____

Parker

Hydraulic and fluid system components

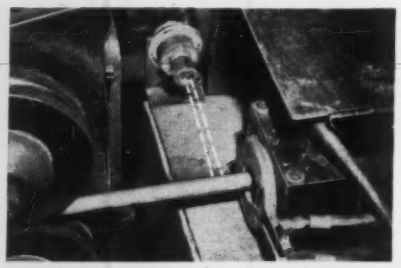
For more information circle **35** on inquiry card.



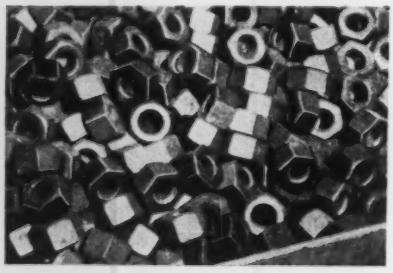
Rayotube (1) detects temp. of heated stock (2) from coils.

Speedomax controller (3) and L&N control unit (4) regulate power to induction coils (5).

Cold bar stock (6) entering coils.



Rayotube (above), positioned only 9" from bar, can be focused on an area as small as 0.1" in diameter at 4". Due to fast, controlled heating, punched blanks (below) are clean . . . scale free.



SPEEDOMAX-RAYOTUBE "TEAM"
READILY CONTROLS

H-F induction heating

AT LAMSON & SESSIONS CO.

• Thanks to a Tocco high frequency induction heater and L&N Speedomax® temperature control, the Lamson & Sessions Company's East 63rd St. plant in Cleveland not only increases its nut-forming capacity but at the same time eliminates rejects due to scale.

This equipment replaces two conventional hot punching machines and increases capacity 50%. Round bar stock is first fed into the coils of the 3,000 and 10,000 cycle induction heaters. As the hot bar emerges, it moves into a cut-off and nut-forming machine which produces 4200 blanks an hour. The formed nuts drop into an oil quench . . . are later picked up by a steel conveyor.

Despite changes in line voltage, or in bar size, composition or speed through the induction coils, the equipment's Rayotube® detector, in combination with its Speedomax controller, keeps bar at uniform forging temperature. The Rayotube sights directly on the hot bar as it emerges from the coils . . . rapidly follows its temperature changes. If temperature is above or below 2350 F, the Speedomax throttles a motor-operated rheostat to regulate power input to the induction coils . . . and thus keeps bar at desired heat.

If you'd like more details about using the L&N Rayotube and Speedomax team on high frequency induction heating or similar applications, just write us at our nearest office, or at 4955 Stenton Ave., Phila. 44, Pa.

LEEDS NORTHRUP
instruments *automatic controls* • *furnaces*

For more information circle **36** on inquiry card.

Editorial...

INSTRUMENTS and AUTOMATION

Report on

Second International Automation Exposition

Within two brief years the Automation Exposition has established a unique character and personality.

The word automation, despite myriad interpretations, has become associated in the minds of most persons with any technique leading to automatic production, including automatic fabrication, automatic assembly, automatic parts handling, automatic data handling, automatic computing, and automatic control in all its forms. Whereas each of these phases of automation has been well represented individually in the older trade shows devoted to instrumentation, production engineering, or automatic production, the Automation Exposition differs from other trade shows in that it offered exhibits of advanced equipment for all phases of automation, thus providing a valuable and much-needed perspective of the entire field, and re-emphasizing the broad nature of automation.

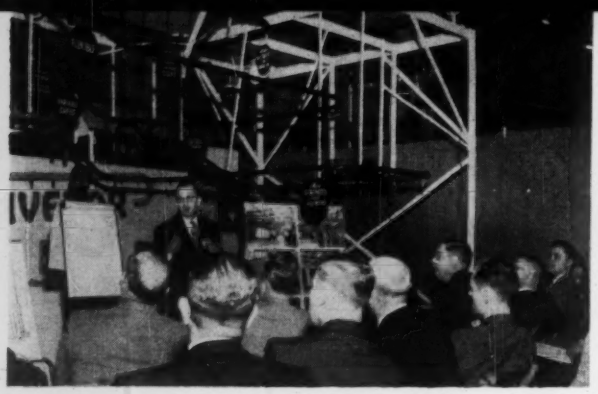
The broad representation of automation equipments was matched by the attendance at the Show, which also was characterized by diversification. Unlike traditional shows, which have exhibited a tendency to specialization in both equipments displayed and visitors attending, the Automation Exposition was characterized by great depth in background of attendance. This is a healthy tendency that may break the vicious circle of specialization in which heavy emphasis on certain types of equipment attracts specialists in that field, discouraging persons in related fields and in turn leading to still greater specialization. The broad appeal of the word automation no doubt led to both the broad nature of the displayed equipments and to the attraction of visitors from all segments of industry, finance, education, and labor. The attendance was thus a unique cross-section of American industrial and financial life, with heavy emphasis on executives who find automation a new and provocative concept.

As was true of the First Automation Exposition, the Second Exposition drew many foreign observers. A group of Russians spent four days at the Exposition, and examined in detail the ITV systems of DuMont, General Precision Laboratory, and Dage Television; the automatic electronic chassis fabricators (such as the Protomaka of Printed Electronics and the Brush wiring machine); the remote supervisory systems of Femco, Hammarlund, and Radio Frequency Labs; and the many exhibits of computers and machine-tool controllers.

Observers from the manufacturing industries were attracted to the equipments for automatic fabrication, automatic wiring of chassis, and automatic machine tool control. Exhibits in these fields were offered by: Alden Systems, The Austin Company, Automation Corporation of America, Automation Engineering Laboratory, Barnes & Reinecke, E. W. Bliss Company, Brush Electronics-Clevite Research, Burndy Engineering, Design Tool Corporation, Eriez Manufacturing, Farrand Optical Company, Farrara, Mechanical Division of General Mills, Russell T. Gilman, Hycon Manufacturing Company, Pak-Rapid, and Printed Electronics Corporation.

These exhibits included techniques for the automatic etching of printed circuits, the automatic wiring of

Second Automation Exposition (Chicago, Nov. 14-18) featured 211 booths and 21,880 square feet of exhibit space.



Conveyor Clinic session. Class received two-hour lecture on techniques for automatic materials handling. This session was conducted by Chainveyor Corporation. Other Conveyor Clinic sessions were conducted by Jervis B. Webb Co.; Mechanical Handling Systems; and Gaudreau-Rimbach Associates. A total of 160 men registered for these four clinic sessions.

D. J. Laughlin (Teleregister Corp.) conducts Computer Clinic Session on advanced techniques for data handling, carrier reservation systems, inventory control, etc. Other computer clinic sessions were conducted by The Austin Co.; Berkeley-Beckman; Bendix Aviation; Clevite-Brush; Goodyear Aircraft; Electronic Associates; International Business Machines Corp.; and Librascope. Computer Clinic sessions drew an attendance of 375.

Armand Gaudreau, Consulting Editor of *Instruments and Automation* and director of the Conveyor Clinic conducts session on plant layout.

chassis, the automatic placement of components on chassis, automatic packaging, etc.

Materials Handling

Although the word automation originated in the field of parts handling, this phase of automation has often been ignored in the common treatment of automation as an all-inclusive word for automatic production. Not so at the Automation Exposition. Advanced techniques for the automatic handling of parts, materials, garments, etc., were exhibited by Chainveyor Corporation, Mechanical Handling Systems, and Jervis B. Webb Co. These exhibits did much to round out the complete picture of automation presented.

Process Industry Automation

Dramatic control centers for the process industries, featuring direct print-out of process variables, were shown by Panellit (exhibiting the new Panalog 605 process monitor-logger), Fischer & Porter, and Hays-Metrotype. Other control panels were displayed by DuBois Engineering & Mfg. Company, Industrial Control Panel Company and Scam Instrument Corporation. The list of exhibits of more conventional process instrumentation for pressure, temperature, strain, weight, electronic test equipment, servos, etc., is too long to repeat here—it begins with the A's (Allegany, American Helicopter-Fairchild, Analytical Instruments, Assembly Products, Automation Instruments, and Avion) and extends to the Z's (Zenith Electric and Zoomar).

Components

The component is the bread-and-butter item of automation, with applicability limited only by the imagination of the user. Here again, the large number of exhibits of components prevents an individual listing; the highlights were many new switches, relays, precision gear trains and servo-mechanisms.

The field of counters and counter controllers was well represented by Atomic Instrument Co., Counter and Control, Post Machinery, Production Instrument Co., Spencer Manufacturing, and Veeder-Root.

Computers and Data Reduction

Highlight of the Automation Exposition was the exciting array of equipments for data reduction and computing, an array comprising more than 50 booths, and including magnetic tape data recorders, punched paper tape readers, memories of all types, analog computers, digital computers, special-purpose computers, analog-to-digital converters and digital-to-analog converters.

These equipments were exhibited by: Austin Company, A-V Manufacturing, Benson-Lehner, Berkeley-Beckman, Bendix Aviation, Brush Electronics, Clary Corporation, Coleman Engineering, Computer Control Company, Davies Laboratories, Electronic Associates, Epsco, G. M. Giannini, Goodyear Aircraft Corporation, Instrument Development Laboratories, International Business Machines Corporation, International Standard Trading Corp.-IT&T, Kleinschmidt, Librascope, Logistics Research, Metrotype Corporation, National Cash Register Company, North American Aviation, Potter Instrument Company, J. B. Rea Company, Soroban Engineering, Teleregister Corporation, Vanguard Instrument Corporation, Victor Adding Machine Company, and Western Union Telegraph Company.

This is a remarkable listing of data equipments. The number of plant and office data problems discussed at the Exposition by the equipment specialists and show visitors must be in the order of thousands.

Office Automation

Yet another unique feature of the Automation Exposition was the interesting coverage of techniques and

Show attendance was a unique cross-section of industry, finance, education and labor. Also attracted were many foreign observers, including a group of U. S.-State-Department-led Russians.

equipments for office automation, a field whose growth rate is climbing sharply. Many of the computer and data handling exhibits listed above featured office equipments, and a new book, *Office Automation*, was offered by Automation Consultants, Inc., in an entire exhibit devoted to this one product.

First Disclosures

Among the many disclosures of new equipments at the Automation Exposition were the new LGP-30 General-Purpose Digital Computer of Librascope (which will be described in a feature article in the near future), a new line of statistical tools by Electronic Control Systems of California (statistical analysis of frequency distribution, continuity checkers, and others), new plastic fittings for plastic tubing by Tube Turns Plastics (featuring surfaces for hand-tightening), new Zytel (polyamide resin) plastic tube fittings by Crawford Fitting, and new "400 Series Capacitrol" process controllers by Wheelco.

Automation Handbook

The Automation Exposition is unique in yet another respect, and one that may be of greater importance than its breadth and depth of exhibits and attendance. The Automation Exposition is the only American Trade Show that is completely described in book form. Every exhibit is reported in a technical and noncommercial manner in the *Automation Handbook*, a complete 230-page pictorial-technical report of every exhibited product. Each registrant at the Exposition received this *Handbook*, whose function is much more than a program of the Show. The *Handbook* permits him to take back into his plant or office a detailed account of every exhibit, which can be circulated and examined for applicability to industrial operations. Thus, although the Automation Exposition closed its doors on November 18, 1955, thousands of visitors are still examining every exhibit in terms of individual needs. The *Automation Handbook* transforms the Automation Exposition—the Show of the Future—from a four-day trade show into a 365-day market place for the expansion of automation techniques, in all its manifestations, throughout the plants, factories, offices, and laboratories of America. This is a pattern for progress.

Dear D. R.*:

Here it is—the last issue of 1955, and the last page of this issue is page 2150. Bet you didn't know that your twelve issues of I&A this year comprised more than 2100 pages, *plus* a 278-page Catalog & Index! Included in this were 2313 New Product reviews and 2346 New Literature items, all indexed. And wait till you see what's coming next year!

We want to point out a few items of particular significance in this issue. First, be sure to read and study the article on Diode Matrices in the series on Digital Automation. Last month you learned fundamentals of binary arithmetic. This month you put the binary to work with the matrix—and what results is a joy to behold. Read it yourself and find out.

Secondly, the J&L Steam Generating Facility shown on the cover and described in an article is unique. This boiler house really stays on automatic control!

See if you agree with our opinion of Clyde Williams' article "Trends in Research." We think it is the clearest picture of the research scene yet painted.

And if you have a moment to let us know how you like this issue, we will appreciate it. Meanwhile, a Merry Christmas and A Happy New Year!

Cordially,
Milt and The Editors

*Dear Reader

ISSUES

The Counter Reads 0|0|3|3|6

and thereby registers the end of twenty-eight years of *Instruments and Automation's* service to users of measurement and control devices—service to THE UNITED STATES OF AMERICA

The entire staff of *Instruments and Automation* wishes you

Season's Greetings

Brown Thermocouple Protecting Tubes for Every Application

The protecting tube is just as important as the thermocouple with which it is used. It not only safeguards the couple from mechanical damage, but also extends its useful life and preserves its accuracy by preventing corrosion from the medium in which the couple is inserted.

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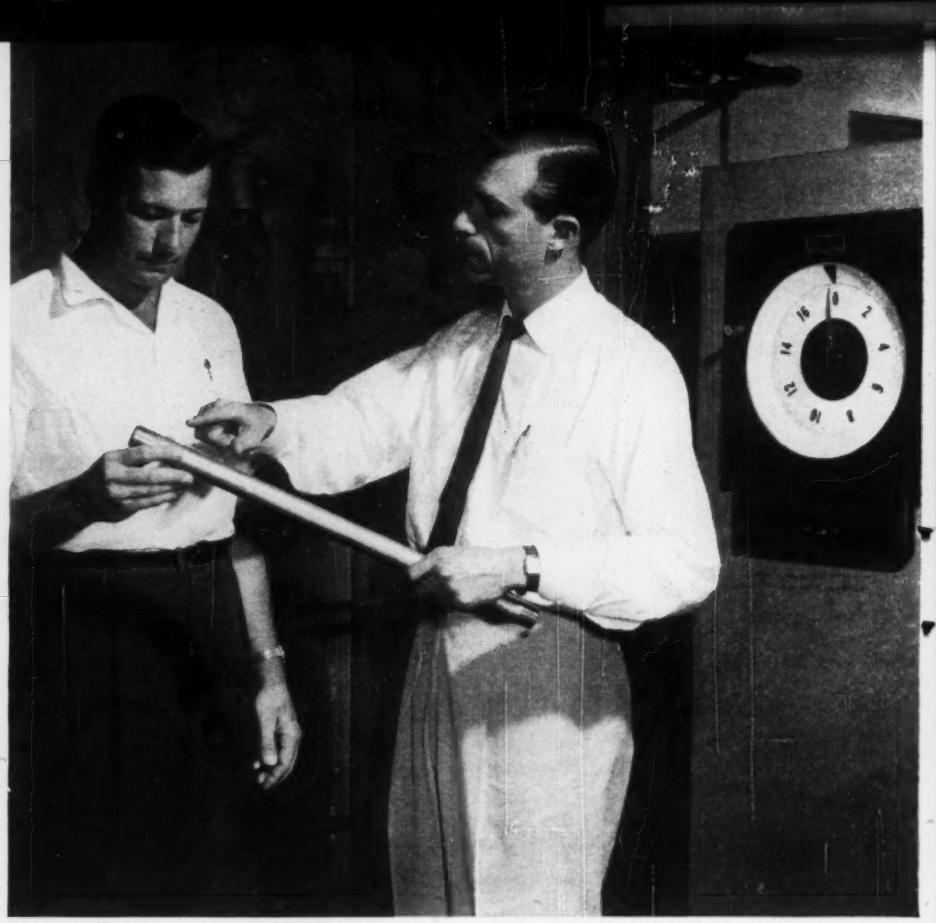
Metal protecting tubes, applicable to many heat-treating applications, are available in a choice of alloys . . . including carbon steel, cast iron, *Inconel*, nickel, *Resisteat* (28% chrome iron), stainless steel and wrought iron. Maximum temperature service ranges from 1000 to 2200 F, depending on the alloy. All are manufactured to strict specifications.

Ceramic protecting tubes are generally used where temperatures exceed 2200 F. They are made from various specialized materials. Sillimanite, fused silica and *Vycor* are used as primary protecting tubes . . . with maximum temperature ratings of 3000, 2300, and 1800 F respectively. Many high-temperature installations require a secondary outer protecting tube, which can be firebrick, silicon carbide, or *Mullite* depending on the application.

Your local HSM will be glad to investigate the requirements of your specific installation, and to recommend the Brown protecting tube that will give you the best service.



Here's why it pays to know your HSM
HONEYWELL SUPPLIES MAN

FRANK LONG, HSM (Honeywell Supplies Man) in the Houston area, points out advantages of Brown thermocouple protecting tubes to Travis Reese, at left, Supervisor of Tools and Supplies at the Cameron Iron Works, Inc., Houston.

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Biographies of Significance

"Jake" Groenewegen

SIGNIFICANCE

J. C. Groenewegen is known affectionately and well as "Jake" throughout the process industries. The brief biographical data which follow reveal the growth of plant instrumentation within his fruitful lifetime, and emphasize the change in complexion of the instrument department from a small maintenance group to the modern large control center for complex processing equipment. Jake has been overly modest in his treatment of his contributions in this evolutionary development. Nor did Jake mention his important work for the Southern California Meter Association (SCMA), the several Los Angeles Harbor Short Courses on Instrumentation, the maintenance clinics of the ISA National Conference, etc., etc. Jake has been a key figure in process instrumentation for three decades. It is a pleasure to introduce him to you, and to acknowledge his contributions to the field.

J. C. GROENEWEGEN

J. C. Groenewegen was born in 1903, but suggests that his biography be based on his job with "Shell," because he began his instrument career with Shell in December, 1923—32 years ago! He was with Shell Oil to '43, and then Shell Chemical to '48, and then back to Shell Oil to '50, and back to Shell Chemical again, where he is now head of the Instrument and Control section, Shell Chemical, Torrance, Calif.

It all started out as a one-man affair. Jake was THE instrument man.

How did it happen? In his words "I had worked in the machine shop and also in the electric shop. The plant being built at that time was to have something new—instruments, mainly for measuring temperature. Since I happened to have both mechanical and electrical background, I was somehow declared to be the 'instrument man'."

Within a relatively short time Jake had an understudy, and inside of a year the one-man operation had become a three-man affair.

Today, due to further expansion during the years and an ever-increasing number of control instruments, that group numbers thirty.

Originally, temperature and pressure instruments were the sole responsibility of the group. Today, Jake's Instrument and Control Section is in charge of all types of control equipment on complex processing equipment, as well as plant and laboratory analytical instruments, and including pneumatic, hydraulic, mechanical, electrical and electronic equipments.

This year another experience came Jake's way. Shell acquired a plant that produces synthetic rubber. This will likely bring new problems and the need of new methods of control.

Jake is a member of the SCMA, the ISA, and the California Natural Gasoline Association.

Jake tells us, "I have subscribed to I&A for 27 years—believe my first copy was Vol. 1 No. 6 (June, 1928)! Every copy has been a valued source of info. which applied to my job."

SIGNIFICANCE

One object of our biographical reviews is to bridge the gap between the fields of process instrumentation and computers, particularly to the end of introducing simulation technique into the instrument department. Robert Howe is an important figure in the Midwestern Simulation Council, serving as the first chairman of its Steering Committee. It is a pleasure to introduce Professor Howe.

ROBERT M. HOWE

Robert M. Howe was born on August 28, 1925. He attended both Oberlin College and the California Institute of Technology, receiving his B.S. degree in Electrical Engineering from Cal. Tech. in 1945 and his A.B. degree in Physics from Oberlin in 1947. From there he went to the University of Michigan, from which he received the M.S. degree in Physics in 1948. While at Michigan during this period he first became interested in analog computers and accomplished some of the early research in application of electronic differential analyzers to a wide range of engineering problems. In this and future work he collaborated with his father, C. E. Howe, who is a professor of Physics, Oberlin College.

In 1948, Bob left Michigan to go to Massachusetts Institute of Technology, where he received his Ph.D. in Physics in 1950. His doctoral thesis was in the field of mercury-arc discharge. He then returned to the University of Michigan as an instructor in the Department of Aeronautical Engineering, where he currently holds the rank of associate professor. Dr. Howe teaches graduate courses in instrumentation, automatic control, guidance and control of aircraft and missiles, nuclear engineering and design and application of electronic differential analyzers. Since returning to Michigan his research efforts have been largely in analog computers.

Continued on page 2031

another outstanding feature . . . REEVES

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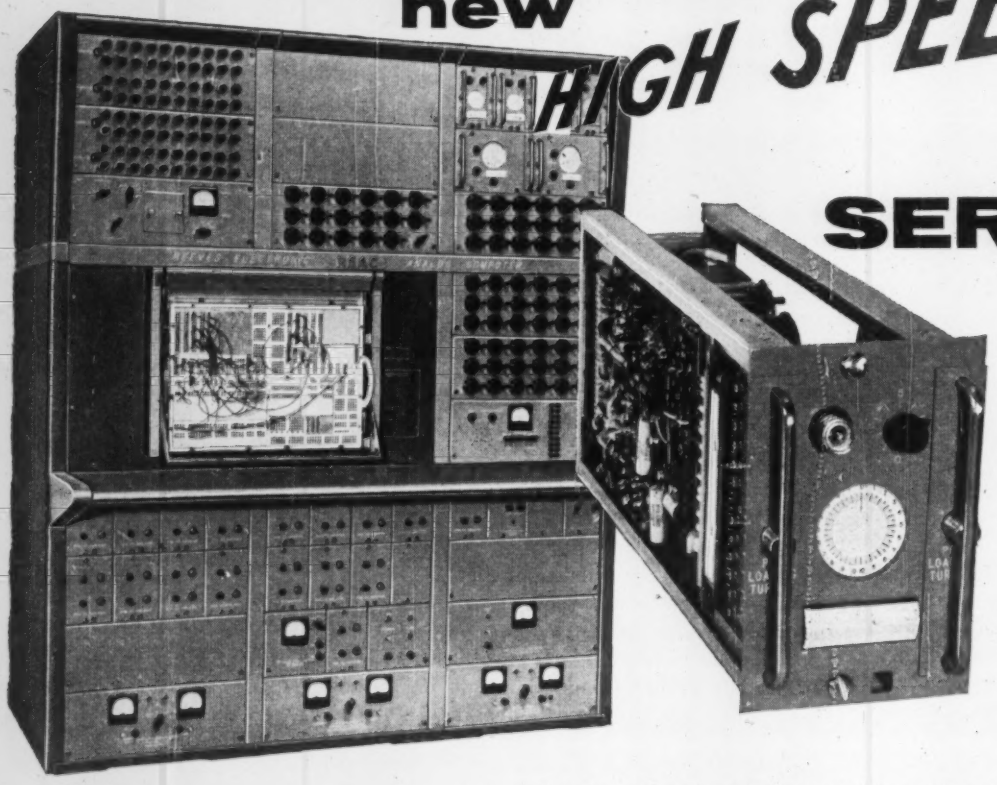

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Vastly improved dynamic performance . . . 35-cycle bandwidth.

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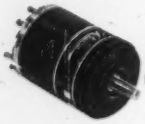

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BIOGRAPHIES—Continued

How did Bob Howe get into simulation work? While he was doing graduate work at the University of Michigan, the Aeronautical Engineering Department ran into a problem involving simulation of a missile system (part of a government project on guided missiles). They started to simulate with a mechanical analog, but soon switched to an electrical analog. The Aeronautical Engineering Department now has a 150-amplifier simulation facility with 20 servo-multipliers. The analog computers are used extensively in graduate work and, significantly, are starting to be used in undergraduate work in A.E.; all aeronautical engineers with a B.S. degree from Michigan will know how to use analog computers.

Dr. Howe served as the first chairman of the Steering Committee for the Midwestern Simulation Council, and currently is an active member of the Steering Committee. He is a member of Phi Beta Kappa, Tau Beta Pi, Sigma Xi, the American Institute of Physics and the IRE.

SIGNIFICANCE

THE biography of a young engineer whose published works already include more than 40 articles has much to teach, particularly when the major field of application has been instrumentation. Each new development in instrumentation, each solution to the myriad problems facing the instrument man every day, paves the way to higher accuracies, new techniques, new vistas in instrumentation. Mr. Kaufman is a solver of unique instrument problems—and he hastens to inform the entire instrument fraternity of each of his many developments. The combination produces a powerful and important figure. We take pleasure in introducing Mr. Alvin B. Kaufman to you.

Alvin B. Kaufman

ALVIN B. KAUFMAN

MR. Kaufman was born in Jacksonville, Florida, on October 9, 1917. He received a degree from Los Angeles City College in 1938. From 1939 through 1952 he was with Douglas Aircraft Company, performing flight-test instrumentation, research, development testing, and engineering supervision of electronic components receiving inspection. From 1952 to the early part of 1955, Mr. Kaufman was employed by Northrop Aircraft, Inc., where he supervised, administratively and technically, the laboratory and on-board calibration and checkout of the Snark Missile instrumentation systems.

In July of 1955, he joined the staff of the Arnoux Corporation, as a Project Engineer to supervise development of temperature measurement systems, missile instrumentation, and as an engineering consultant on missile instrumentation projects. Mr. Kaufman is a member of IRE. His hobby is amateur radio (W6YOV) and technical writing. He has had published over forty papers, and has four patents pending.

Mr. Kaufman is known to readers of *Instruments and Automation* as author of "How Accurate Are Your Temperature Reference Baths"* (*I&A*, March, 1955), "Telemetered Temperatures" (*I&A*, Aug., 1955), and "Microscope Techniques for Accelerometer Calibration"* (*I&A*, Sept., 1955). His article "Measurement of Damping and Natural Frequency" appears on pages 2104-2108 of this issue.

*Co-authored with Mr. P. R. Mitchell

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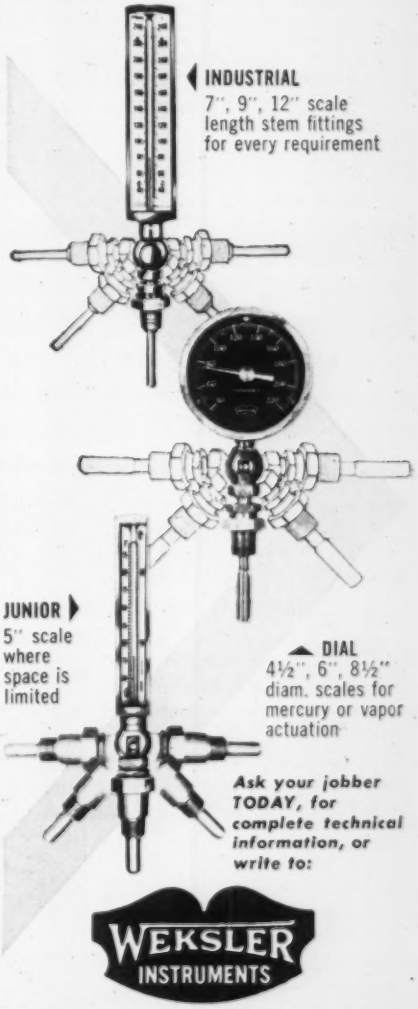
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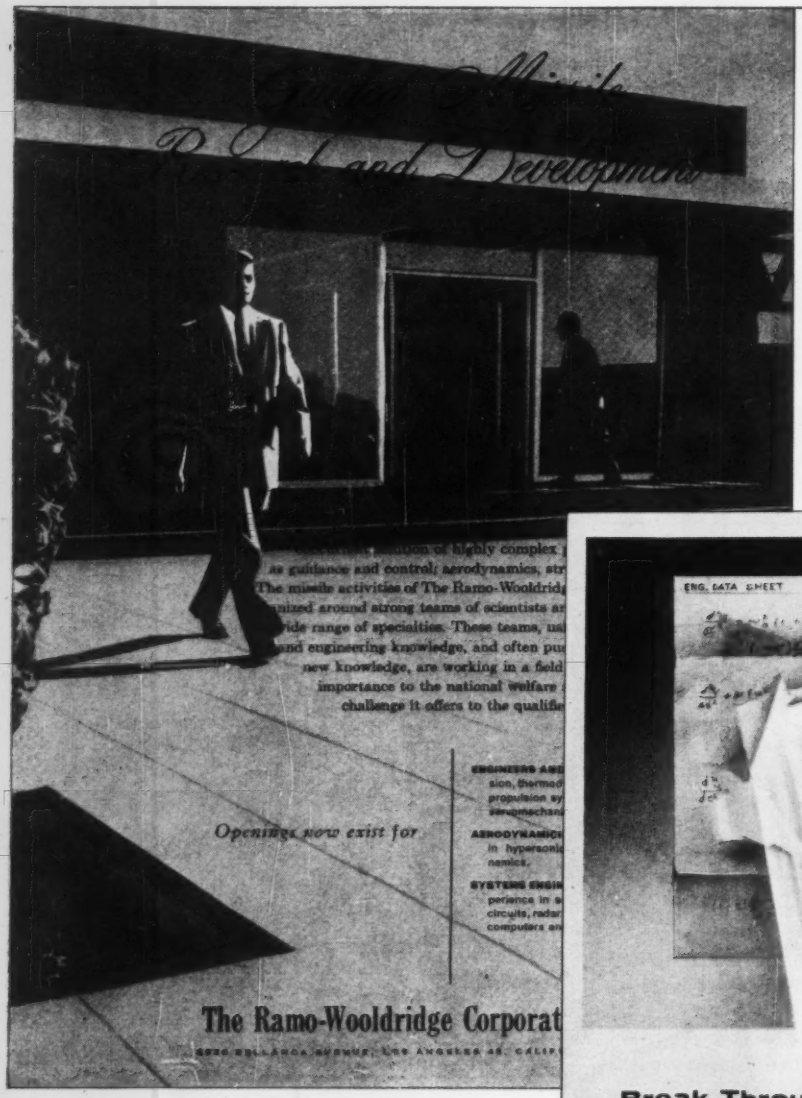

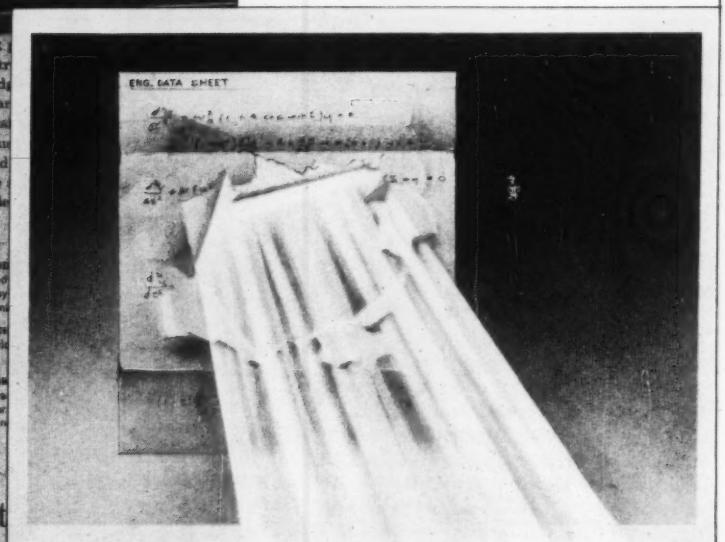

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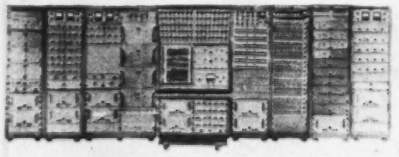
More and more engineers are turning first to Electronic Associates' Analog Computing Groups to conquer the problem barrier. For in these Groups they find an unparalleled accuracy, reliability and flexibility that has been proved by thousands of operational hours. These groups feature a building block method that simplifies the economical expansion of the system by the addition of standard component groups. A complete Group and staff is available for your experimentation on a rental basis at Electronic Associates' Computation Center just outside of Princeton, New Jersey. We will also gladly furnish details on our new line of high-speed sounds, problem checks, high accuracy Electronic Multipliers, Function Generators and precision output equipment. Write Dept. IA-8.



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ELECTRONIC ASSOCIATES *Incorporated*

EAI SETS THE P A C E
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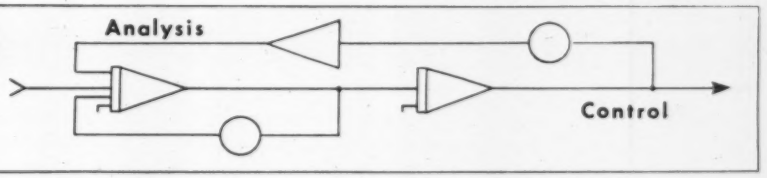
The SIMULATION COUNCIL Newsletter



John H. McLeod, Jr., EDITOR

Suzette McLeod, SECRETARY

1891 West Chapel Drive
Camarillo, Calif.

Western Simulation Council
Norman L. Irvine, Aerojet-General Corporation, Azusa, Calif.; Chairman, Steering Committee.

Midwestern Simulation Council
R. R. Weber, Cincinnati Milling Machine Co., Cincinnati, Ohio; Chairman, Steering Committee.

Eastern Simulation Council
Harold K. Skramstad, National Bureau of Standards, Washington, D.C.; Chairman, Steering Committee.

Southeastern Simulation Council
W. K. McGregor, ARO, Inc., Tullahoma, Tenn.; Chairman, Steering Committee

Bits

Well, if your Newsletter isn't interesting this month, the reason is not lack of material. Fact, I've got so much I'm going to hold the Eastern Simulation Council meeting of 19 September (at Glenn Martin on "Computer Checking Procedures") and the Midwestern Simulation Council meeting of 14 November (in Chicago on "Patchboard Systems for Analog Computers") over till next month so I can give you the news on the formation of our newest group, the Southeastern Simulation Council, and our November meeting of the WSC.

Got the notes on the organizational meeting of the SSC and boy, it sure looks as if that bunch is on the ball. They started quite logically by having representatives tell what equipment they have and what they do or expect to do with it. Then they discussed what "worthwhile" things their Council might do. Came up with three very good suggestions too.

Remember when *we* were ambitious and tried to set up a worthwhile project for our original WSC? Your Ed. even tried some art work for the first (and last) time in his life. Under caption "We've Now Got a Project That Needs Attention" I drew my version of an abandoned baby on a doorstep, obviously in need of attention. Our project was to be the standardization of multiplier specs. We didn't get far, but if these Southeasterners keep going as they've started, they have a good chance of succeeding. We should all wish them well, and help where we can, because our Simulation Council is becoming recognized nationally and any contribution that one of us makes to the field benefits us all. (More on the National Simulation Council trend next month.)

As for our WSC meeting, I attempt to report that in this issue too, but I am not equal to the task of adequately describing John Stroud who is, by his own confession, "a physicist who wandered into psychology rather late in life". And if I accurately described his opinion of man as an element in closed-loop control, Dick Rimbach would have trouble with Uncle Sugar's Postal Inspectors for sure. Characters! ! ! I love 'em!

Pieces

ORGANIZATIONAL MEETING OF THE SOUTHEASTERN SIMULATION COUNCIL

Arnold Engineering Development Center, Tullahoma, Tennessee on 30 September 1955*

Those attending this meeting were given a briefing and fast rubbernecking tour of the AEDC by Jack Shea and his associates of the publicity office, AEDC. This consumed the morning hours.

Steering Committee Meeting

At 12:00 those interested in the Steering Committee meeting convened to discuss the issues concerning formation of the Council. This meeting carried a distinctly informal note. It was decided by those present that organization should continue to be kept informal but not so much so. To summarize, the organization is presently to be:

A steering committee having eight members and two officers, who for the first year will be:

W. K. McGregor, ARO, Inc., Tullahoma, Tenn. (Chairman)

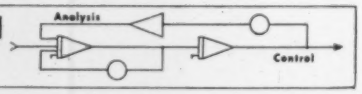
W. H. Bradley, Murphy and Cota, Atlanta, Ga. (Secretary)

E. R. Mann, Oak Ridge National Lab., Oak Ridge, Tenn.

R. F. Waddey, U. S. Navy Mine Defense Lab., Panama City, Fla.

F. E. Digesu, Redstone Arsenal, Huntsville, Ala.

*These notes were sent to me by W. H. Bradley, the Secretary of the SSC, but I note that they were initialed by W. K. McGregor, the Chairman of the Steering Committee, so I don't know who wrote them; whoever it was did a fine job.—Ed.



M. D. Prince, Ga. Inst. of Technology, Atlanta, Ga.

And two members to be appointed.

General Meeting

The meeting was opened by *W. K. McGregor* (Engine Test Facility, ARO, Inc., Tullahoma, Tenn.). He introduced *John Wild*, Director of Engineering of ARO, Inc. Mr. Wild welcomed the Council to AEDC and expressed his interest in the formation of the group. He compared the Simulation Council to a group now meeting to discuss wind-tunnel operation, and to the technical groups of NATO who meet to discuss various subjects of mutual interest among nations.

Mr. McGregor then introduced the topic of the meeting, **"Use of Simulation Equipment in Facilities in the Southeast."** He explained this topic as a "getting acquainted" subject, and called on each organization represented to present a brief description and discussion of usage in their facility. These presentations were followed by a question-and-discussion period. The following summary gives the essentials of the comments:

Digesu on Redstone Arsenal

1. *Fred Digesu*: Redstone Arsenal, Huntsville, Alabama

Equipment: A carrier-type analog computer, originated in Germany, rebuilt and improved at Redstone. Distinguishing feature is a-c integrators using electronic switching.

Use: As a missile dynamics simulator in studies of missile control and guidance.

Discussion: In answer to Mr. McGregor's question, Digesu explained that simulation tables were used for onboard equipment; actual control-actuating equipment is also included in the simulation. Mr. Wild asked if an actual missile simulation in a wind tunnel had been considered—answer was negative.

Mann on ORNL

2. *E. R. Mann*: Oak Ridge National Laboratory, Oak Ridge, Tennessee

Equipment: A home-made nuclear-reactor simulator and some Electronic Associates equipment; equivalent to about 58 operational amplifiers.

Uses: As a nuclear-reactor simulator for use in the design of servo systems for control of the reactor absorbing rods; as a laboratory simulator for other control-system studies.

Discussion: Question: (*McGregor*): "Do you ever use the simulation equipment as the actual control for the reactor?"

Answer: "*No.* We don't try to make this reactor do tricks. The speed with which we move the rods governs the speed of control; the motor just won't run any faster."

Question: (*Schwent*, ARO, Inc., AEDC) "Instead of having a control problem, you avoid a control problem; is that it?"

Answer: "Yes, we try to work around the control problem, to make it a self-stabilizer. I don't know of any failures we've ever had in the control system. Obviously we've been very successful—we are here!"

Stephenson on Patrick AF Base

3. *Lt. C. D. Stephenson*: Patrick Air Force Base, Florida

Equipment: Eleven cabinets of Reeves REAC equipment, including 2 C101 bays, 2 servo multiplier bays, and 6 function generators.

Use: As simulation equipment to aid in determining parameter ranges and other data for use in missile flight testing.

Discussion: In ensuing discussion it was brought out that the simulation equipment is used by the Air Force while the missile testing is accomplished by private operators. The equipment is just beginning operation.

Prince on Georgia Tech

4. *M. D. Prince*: Georgia Institute of Technology, Atlanta, Georgia

Equipment: Digital equipment only; have use of simulation equipment at other locations for use on research contracts; a 40-amplifier EASE on order.

Use: Studying general problems in missile dynamics and trajectory simulation.

Murdock on Sperry-Farragut

5. *R. W. Murdock*: Sperry-Farragut Corporation, Bristol, Virginia-Tennessee

Equipment: None; planning a 50-amplifier facility.

Use: Studies of missile guidance systems; as an aid in analysis of flight-test data, as a training tool for engineers.

Discussion: Some discussion developed concerning use of simulation equipment in connection with flight tests. Mr. Murdock said they planned to capture flight-test data on magnetic tape and play the signals back for the simulation.

Waddey on USN Mine Defense Lab

6. *R. F. Waddey*, U. S. Navy Mine Defense Laboratory, Panama City, Florida

Equipment: A 10-amplifier EASE computer with some non-linear equipment.

Use: In torpedo guidance studies and testing.

Discussion: In answer to a question, Mr. Waddey explained the use of water tunnels* for determining torpedo characteristics.

McGregor on ARO

7. *W. K. McGregor*: Engine Test Facility, ARO, Inc., AEDC, Tullahoma, Tenn.

Equipment: (a) A GEDA facility including an L3, N3, and R5 unit. (b) An EASE facility consisting of 40 stabilized amplifiers, 40 pots, 12 multipliers, and 6 function generators. (c) Miscellaneous equipment consisting of 25 Berkeley operational amplifiers and 6 function generators; and 20 Philbrick K2-W operational amplifiers. (d) A Philbrick fast-time-base facility consisting of about 55 units.

Use: (a) The GEDA is used as a general-purpose simulator for plant control studies, for engine control studies, and other functions.

(b) The EASE is used as an operational instrument for jet engine testing. The unit has not been used as yet, but will be used presently to compute variables in a ramjet engine test.

(c) The simulated variables (altitude and Mach number) for engine testing have closed-loop control systems using analog computer components for the controller. Operational amplifiers are used in error detection and equalization; function generators are used as linearization devices to compensate for operating point parameter changes. The miscellaneous items are used in this capacity.

(d) The Philbrick computer is used as a training tool and also as a

*Suzette want to know if this is anything like the Tunnel of Love, with which she seems to be familiar!—Ed.

fast check for linear controls phenomena.

Discussions: In course of discussion it was brought out that the main use of simulation equipment in ETF is in the actual control. Mr. Schwent stated that the equipment was originally developed for controls in fire-control systems, later as analog computers, now being put back to usage as integral parts of control systems. Mr. McGregor further explained the control system for a new ramjet engine test facility at AEDC which would consist basically of some 110 operational amplifiers!

Peebles on U. of Tenn.

8. *F. W. Peebles*: University of Tennessee, Knoxville

Equipment: None*

Use: A multiplicity of uses was discussed by Mr. Peebles. His particular interest at present is the integration of differential equations derived from chemical engineering processes.

Bradley and Franzel on SE Computer Facilities

9. *W. H. Bradley*: Murphy and Cota, Atlanta, Georgia (Area representative for Berkeley EASE)

Mr. Bradley discussed the various facilities in the Southeast which were not represented at the meeting. These include facilities at Eglin Air Force Base, Florida; Lockheed Aircraft Corporation, Marietta, Georgia; Southern Research Institute, Birmingham, Alabama; University of Florida, Gainesville.

10. *R. T. Franzel*: Reeves Instrument Corporation**, New York, N. Y.

Mr. Franzel was asked to discuss any use of REAC equipment in the Southeast which had not been accounted for. He summarized this use and went on to explain Project Cyclone, which Reeves operates.

A general discussion followed, in which the prime topic seemed to be "What Worthwhile Services Can the Southeastern Simulation Council Render?". Mr. Prince introduced the topic of education in this field. Mr. Waddey explained a 16-weeks' course given at their facility. The consensus of opinion was that the Council could undertake a study of the *education problem**, possibly outlining a course. Another problem facing users and potential users of simulation equipment is factual evaluation of components. It was decided that the Council could very definitely be an aid in this somewhat commercial capacity. Another topic of discussion was whether competent consultants are available for simulation problems. Most people felt that they were not. It was suggested that the Council as a whole probably would be the best consultant because of the variety of experience.**

The meeting was followed by a tour of the Jet Engine Test Facility, with particular emphasis on the use of simulation equipment.

*A good way to keep down the overhead, but makes operation difficult! —Ed.

**Reeves seems to make a real effort to have a representative at every meeting of all four Councils. As long as vendors don't try to dominate, this is very good—it promotes the symbiotic customer-vendor relationship which can be beneficial to both.—Ed.

THE WESTERN SIMULATION COUNCIL

Meeting of 10 November 1955, Beckman Instruments Inc., Fullerton, Calif.
Subject: Simulation With a Human in the Loop

Twenty-nine representatives of 17 organizations met at the corporate headquarters and Beckman Division of Beckman Instruments, Inc. in Fullerton, California the afternoon of 10 November 1955 to discuss **"Simulation With a Human in the Loop."** It turned out there wasn't much discussion, but "we sure got told!"

We've never had a talk like the one *John Stroud* (member of Analysis Staff, Human Factors Division, Navy Electronics Laboratory, San Diego, Calif.) gave us, and that's too bad. He is that all-too-unusual combination of a man who knows his stuff, and is lucid and colorful in talking about it. His enthusiasm is catching, his subject-matter informative, and his delivery amusing. We look forward to hearing him again at the National Simulation Conference in Dallas in Janaury.

Stroud on the Human in the Simulation Loop

After an effective but brief welcome and introduction to Beckman Instruments by *Taylor Fletcher* (Manager, Industrial Instrument Dept., Beckman Division), *Norm Irvine* (our Chairman) said he believed there was a man there who was to speak on humans in the simulation loop. John Stroud then introduced himself, saying "I have no honest duties!"

"What happens when you are confronted with a little black box called 'homo sap'? Ideally I should write out half-a-dozen equations and let you take your choice. Actually all I can tell you is what kind of things we at our laboratory have learned about people and ways to think about them. As for being able to give you something to plug into a computer, unless you phrase your problem pretty exactly and it happens to be one of two or three, I'm afraid I can't help you a bit. I have often wondered why this commonest of all components in systems gets so little attention.

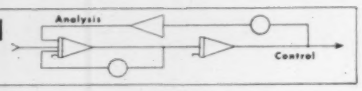
"I have an uncomplimentary attitude toward scientists! The instant they step up to this two-legged black box they forget all scientific training and discipline and become second-rate theologians. You should treat people as if they were components, simulating the rest of the system and literally introducing a human into the system. There is no such thing as *a* transfer characteristic for the human operator . . . you are not going to find *one*."

John continued by saying there is no such thing as a testable open-loop characteristic for a person, except perhaps something like a knee jerk or other simple reflex.

The test wherein a subject moves a lever to put a dot in a moving circle is typical of any real-life situation. In it one doesn't tell the subject what he is expected to do, but just what things should look like. This is giving an error criterion. So the subject is in a closed-loop situation before you can get him to perform. The relationship of the gadget the subject twiddles to the motion of the spot depends on how the computer is hooked up; it could be a perfectly

*Prof. Macduff take note.—Ed.

**Three interesting and very worthwhile projects!



linear amplifier, the inverse of an RC delay, a differentiation, or anything else.

If you bother to set up the implicit demands on the pilot of an ordinary every-day military helicopter, the least that you find you are asking the son-of-a-gun to do is act like a digital differential analyzer which can handle 23 simultaneous differential equations, 7 or 8 simultaneous and more or less redundant inputs, and generate 5 essentially independent time-varying functions of control. The utterly amazing thing is that, if that is what the system requires, that is what it gets.*

You can't tell people what they are expected to do when you use them in systems, only what the results should be. Tell a run-of-the-mill psychologist "Gee, you didn't know you could solve differential equations, did you?" then show him the differential equation describing the problem he just got through solving, and his jaw drops a yard. He might even believe it a little while, but as soon as he gets out into the hall he says "Aw hell, Stroud's nuts."

A first approximation of what man is going to behave like is—whatever is required. The guy is a two-legged general-purpose computer and digital differential analyzer. In the words of Captain Yeager, he is a ham dandy gadget, self-maintaining, self-programming, and produced in large numbers by unskilled labor. In the armed forces they post $10,000 bond for the son-of-a-gun but they don't have to pay up unless they bust him. The chief cost is in the programming.

Being automatic-programming, this guy really gives trouble. He has an enormous memory and very limited computational capacity (which is badly understood). And that memory is all cluttered up with debris from thousands of other problems. So because there is no such thing as erasing the memory, you must find blank space somewhere on the tape if you are to program him to solve the problem presented by the F86 fighter, or to salute the captain when dead drunk, or to do anything else required to make a man in the Navy.

Since you can't program him directly, you have to needle him into programming himself. Then you have quite a mess because the character will always close some loop, but not necessarily the way you intend him to. If you don't give him a route he will do it via scuttlebut or his own crystal ball. Or he will hire somebody to cast his horoscope. But he will close it somehow. He's got to see the consequences of what he does. If he has to dream them up out of whole cloth, and if he has a good enough feedback circuit, we say he's nuts and put him up.

It is quite a job to play detective and find out what loops this two-legged computer did close. Where is he getting his feedback information? He has something over 10,000,000 input channels per eye, and 20,000 others from his ears to his main computing tank. Another set of inputs has to do with long-term memory storage. And using hands and feet to full advantage (as in flying some aircraft) he has at least 24 simultaneous and semi-independent output variables even if you don't consider his fingers.

Another confusing thing is that there are no switches on the outside of this black box, but there are on the inside. And you don't know whether any one of the many inputs is connected or not. He cuts them off when you don't expect him to. By and large a character you are testing is supposed to keep this little spot in the circle. But he goes sort of dreamy and blind and, what do you know Joe? If you can get inside his tank (as you sometimes can), you find he got bored putting that spot in the circle and he was trying to figure out that blonde! He had all the data stored up, and not being a very fast computer he had a hell-of-a-lot of trial programs to run off!!

And all this computer setup in this funny-looking chassis which is man is for the primary purpose of determining the best thing for him to do for himself and for his species. All you can do to get useful work out of him is to convince him somehow that solving a certain problem is the best way of survival for him and/or his species. You will admit this is one devil of an indirect route.

Man is a very complicated general-purpose computer that was not designed for your job and which can be perverted to it only some of the time. Then it may get fatigued, which means that, like the rooster, it ain't going to do what it usta.

At Wright Field there is a DC3 ¾ full of junk to find what happens to "a people" when you put him in the pilot's seat, and the other ¼ to find what he does to the plane. Once a hard-working pilot had just finished a whole day's work. Then they made him fly ILS landings for 24 hours without relief—literally! He was fatigued!! Some tape recordings of what he thought of the Air Force were really classic studies in Basic English, Anglo-Saxon, and a little French. But analysis showed that as far as the ILS landings were concerned his performance had not deteriorated one iota: this is typical of fatigue. People get fatigued not because of the job they are doing, but because of a job they are not doing. Thing that really got this guy teed off was that he wasn't home in bed. There were lots of things he would rather have been doing.

In most real control systems you find that nobody paid enough attention to what the pilot is to be asked to do. You can get a beautiful stack of mathematics which describes the response of the aircraft, but a description of the response expected of the pilot usually amounts to obeying CAA regulations and knowing how to salute the captain. Stroud encourages people (and engineers, too) to write up the mathematical expectations of the operator. But remember, with men you never get a new unit—they're all secondhand, and the manufacturer didn't supply operating instructions. Furthermore they don't work the same twice in a row.

As a simple single-channel amplifier, the maximum usable pass-band of man is something less than a cycle per second in most cases, but there are exceptions. If there is a single frequency input it goes out to 2 cps. It has been demonstrated in air, fatally, that if you try to cram something that runs out to a few cycles (like the response of a fast aircraft) through this character, he makes a bad matter worse. Better he should have stood in bed or frozen on the controls. The ship was inherently stable, but the ship plus the pilot was unstable as hell; the combination pulled ± 8 g's at 2 cycles per second. That's rough! They had to restrict the ship's responses to less than one cycle per second before anyone could fly it.

If you think you are doing homo sap a favor by figuring out and showing him his error, you discover that you automatically wipe about 6 db off his performance. He is built to do this for himself. If you try to help, he tries to out-guess you and

*System named Lola?—Sz

figure backwards what the heck you did to him.

What happens when h-sap acts like a two-channel device? At Wright Field they have discovered that in chasing the circle there is no relationship between errors the sap makes in X direction and those he makes in Y direction. But further pains with cross-correlation showed a nice hefty maximum at a lag of 3/10 second. This is further evidence that when you tell a guy to do two things at once, he doesn't do any such thing. He does two things in as rapid alternation as he can. But any particular case may vary all over the map depending on the day of the week, the stage of training, and the condition of the subject's lovelife.

Certainly a character who cannot handle more than about a bit a second is scarcely bright enough to stay alive. Under some circumstances he *must* have more capacity, and he does. But no matter how they try, nobody has been able to devise a way to get as many as 50 bits a second through a man on a steady-state basis. The highest level—in the 25 to 35 bit range—has been reached by a subject defining a word and pointing to it in a checkerboard pattern at the same time, or by a very skillful pianist playing nonsense music for the first time. If you make some rather simple-minded assumptions that are difficult to justify and go through some very dubious mathematics and try to apply the signal-to-noise theory of Shannon, you wind up with a simply atrocious channel capacity. The amount of information which can be transmitted over a voice channel is usually 5 bits per second (or less) down to the region of 1 or a fraction.

Bob Bemer (Lockheed Missile Systems Division, Van Nuys, Calif.) asked Stroud if he found any correlation between IQ and the number of bits.

John answered not in these simple-minded cases. The chief advantage of a high IQ is that it is easier to trick the son-of-a-gun into doing the crazy jobs. Once you get hold of him you can program him more easily. But sophisticated measurements have been made in painfully few cases. Reports on Bob Mayne's* work with simulated aircraft, work at Franklin Institute, and the unclassified work at Ohio State constitute a large hunk of the literature. Stroud said that if anybody is going to do an adequate job on the subject it will have to be people like those present, not the "people experts." The psychos' advantage is only a neurotic compulsion to work with people; they are not really bright about anything that would be of interest to a hardware merchant.

*Robert Mayne, Manager of Aerophysics Department, IAS

Beckman Div., Beckman Instruments, Inc., Fullerton, Calif.

Only fairly recently have hardware merchants been able to devise problems that were too hard for the two-legged computers to solve, and to build aircraft so responsive that men can't fly them. Formerly there was no question of producing hardware to replace the sap.

Bemer asked, "How do we know the brain has an unerasable storage?"

John then explained that there are three types of memory: There is a short-term one of approximately 1/10 second. There is an intermediate memory like a drum memory, wherein all information is immediately available, with n-dimensional access (e.g., Joe's identity can be recalled in many ways). Items in this memory are self-erasing—that is, items frequently called for have high probability of availability while the availability of those not called for decreases exponentially. This memory is the one we are most likely to be concerned with. Finally there is a long-term memory which we are not likely to run into unless we get clinical. No clinician would advance the thesis that anything which has ever happened to a man is ever forgotten. Evidence indicates that it is not only available and intact but that it is affecting his behavior at the moment. This memory has little or no commercial value in our society; we are trained not to use it, but to write or punch cards.

Bob still wanted to know about re-write, to which John could only reply that little is known about people in this area.

Paul Dennis (Bendix Computer, Los Angeles, Calif.) said, "I should think that perhaps a better hypothesis might be that there are no empty spaces and that you have to record on top of something else."

John said this would be OK if it were not for the orthogenetic development—that is, the machinery ain't all here to start with. The son-of-a-gun builds itself too. What we don't know about people is something wonderful and fearful to behold.

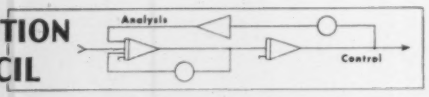
Norm Irvine asked whether there is any indication that we can insert a black box between the knob and the motion of that dot which will then give the least amount of error over-all.

John replied that a few such black boxes are the pride and joy of some people. There is a class of problem in which it is better to do what he had previously told us would not help. Where the frequency and range of the variable are very large, it is sometimes advisable to compute an error for homo sap. Systems such as position-aided rate control (wherein movement of the control changes rate of change and may also insert a step in the value of the variable) are used. Position and rate-aided acceleration control have also been used. But you can always gain more by increasing the pass band than by increasing the accuracy of resolution.

John sketched a system having five integrations in a row and asked, "What would happen if you tried to steer it? People would go nuts. It couldn't be done. People have a tough enough time to do one integration, two is near their limit. And I have never seen the guy yet who could solve three."

George Smith (Ryan Aeronautical, San Diego, Calif.) disagreed, saying that they have a test vehicle for a vertical takeoff jet which they can put up without automatic control, and a man can fly it for at least 30 seconds! Stroud answered that that is something yet again.

You can make a black box which will take samples of each integration and sum them (which is like the



Sperry Zero Reader) and adjust the constants empirically, preferably with the guy in question at the controls. However, you can get an approximate adjustment by substituting a simple amplifier. (This is called Quickening and Unburdening by Henry Birmingham and Frank Taylor of the Naval Research Laboratory.) Now if a guy pays attention not to the feedback of the real system but to this index of the behavior of the real system, he can follow a step input. With the real system he would have gone hogwild. If you know the system cold, which you should if you designed it, there is no reason why you shouldn't do this kind of computation for the sap. The principle behind all black boxes is simple. They should in general do for the guy what he otherwise would have to do for himself. The human should be a simple amplifier.

With a simple amplifier in place of the operator you will realize that you have a servo loop. So why not put the amplifier in and throw the man overboard? Often this *is* the wisest policy.

Information (Without Theory–Or Comment)

"Editors
Simulation Council Newsletter
Post Office Box 731
Camarillo, California

Dear Sirs,

With respect to the publication "DDA" by George Forbes, the first two chapters are inadequate and I tell that to Mr. Forbes every day when he passes my desk. The subject of programming is somewhat, difficult, thus the book definitely needs some clearly written basic material, especially in chapters one and two.

As it stands you can get much out of this book by starting with chapter three but that would make the scaling difficult to understand. It is best to get the information on how a particular machine works from the manufacturer's instruction books.

The whole book (some twenty-five chapters), which is not yet available to the public in its entirety, is packed with valuable information on programming for the DDA. Not all of it is easy to follow due, in part, to the nature of the material. However, Mr. Forbes' book is an excellent guide to the generation of functions. The method of function generation is common to differential analyzers of the type. I have urged Mr. Forbes to rewrite completely the first two chapters with the idea that the book may be used for instruction as well as reference.

Very truly yours,
Frank Verano
7153 *Hesperia Avenue*
Reseda, California

"Dear Suzette,

I have no objection to your publishing Frank's letter if you wish. Frank had considerable experience at MIT working on their elaborate mechanical-electrical Bush type analyzer.

Best wishes,
George Forbes
10117 *Bartee Avenue*
Pacoima, California"

Computer Events

other events on page 2010

You Are Invited

The Chairmen of the various Simulation Councils often receive letters from men who want to come to the Council meetings, and who ask permission to do so. This is not necessary. The Councils are informal groups; all who wish to come may do so at any time; no advance permission is required. Anybody interested in simulation technique is not only cordially invited to attend any of the Simulation Council Meetings but is urged to do so. We need your thoughts. To help you know what to expect, some brief program notes will be included in each calendar item in the future.

Western Simulation Council
Date: 12 January 1956
Place: Ramo-Wooldridge Corporation, 8820 Bellanca Avenue, Los Angeles, Calif.
Time: 1300
Subject: Noise — Analog-digital combinations

Midwestern Simulation Council
Date: Jan. 19, at the National Simulation Conference, Dallas, Texas.
Subject: Group meeting in conjunction with all four Simulation Councils. Representatives of each Council will review the functions and contributions (past, present and future) of his group. General subject will be "What Can Simulation Contribute to Automation?"

National Simulation Conference
Dates: 19-21 January 1956
Place: Baker Hotel, Dallas, Texas
For information write Louis B. Wadel, General, Chairman, National Simulation Conference, 3905 Centenary Dallas 25, Texas.

Western Joint Computer Conference
Dates: 8-10 February 1956
Place: San Francisco, California

High-Speed Computer Conference
Dates: 14-17 February 1956
Place: Louisiana State University, Baton Rouge, Louisiana
For information write Dr. Leon C. Megginson, Department of Business Administration, Louisiana State University.

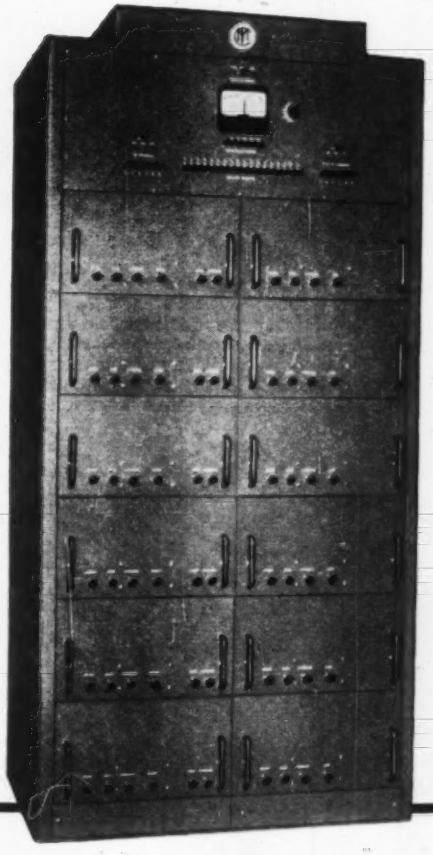
Midwestern Simulation Council
Date: March 12, 1956
Place: Cincinnati Milling Machine Company.
Subject: Mathematical Formulation and Transfer Functions. Discussion will emphasize (1) Mathematical formulation or direct formulation? (2) How to set up transfer function most effectively? (3) Are you simulating or computing?

IRE National Convention
Dates: 19-22 March 1956
Place: New York, N. Y.

ISA and ASME
Dates: 26-27 April 1956
Place: Hotel Bradford, Boston, Mass.
Subject: Conference on Electrical Recording and Controlling Instruments. For information write E. T. Davis, Leeds & Northrup Co., 4901 Stenton Ave., Philadelphia 44, Penna.

Thots

Hal Tremblay (U.S. Naval Air Development Center, Johnsville, Pa.) writes that Dr. Murray of Columbia says that when it comes to analog-versus-digital some people remind him of the old Tammany Hall saying: "Claim everything, concede nothing and demand a recount!"



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- ☐ MC-400 Analogue Computer
- ☐ MC-500 D-C Analogue Computer
- ☐ MC-600 Six Channel Electronic Function Generator

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New Instruments...

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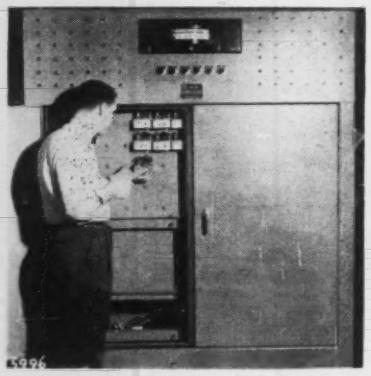


also means for adjusting individual temperatures whenever any point is out of limits; can scan and control up to 72 stations. It utilizes "Multronic Capacitrol," neon pilot lights, pulse-actuated stepping switch, pulsing timer, and small two-tube non-indicating controllers. It automatically checks temperatures at all control stations in a fixed time interval (e. g. 72 stations in less than 4 min); gives visual and audible warnings of off-limit points, indicates departure and corrects automatically.—*Wheelco Instruments Div., Barber-Colman Co., Rockford, Ill.*

For more information circle **201** on inquiry card.

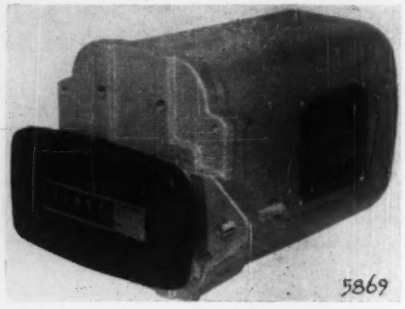
Level Controller

New "Pneutronic" level controller is said to combine "the greatest practical advantages of both electronic and air pressure control instruments." It utilizes electrical capacitance primary elements to detect minute changes in levels. Electrical signals are then converted by control instrument into proportional pneumatic output sufficiently powerful to operate control valves and other pneumatic control equipment: no servomotors and other re-balance mechanisms. Because of modulating control action, much of the wear caused by on-off systems is avoided. "Pneutronic system is largely unaffected by external changes in voltage, air supply, temperature and pressure; provides high-speed response; can be adjusted to give full change of air pressure output for a two-foot change in level of a hydrocarbon or similar low dielectric material.—*Fielden Instrument Div., Robertshaw-Fulton Controls Co., 2920 North Fourth St., Philadelphia 33, Penna.*

For more information circle **202** on inquiry card.

Centrifugal-principle Flow Integrator

New "Model 14A Pneumatic Integrator" provides continuous linear integration of flows to within 0.5% accuracy. Principle: 3-15-psi measurement signal (from a d-p transmitter) positions a force bar in relation to a nozzle. Resulting back pressure at



nozzle governs an air jet which drives a turbine-wheel. A weight pivoted on this wheel produces a centrifugal force, which acts on force bar to balance measurement signal. Measurement signal varies as square of flow-rate; turbine weight's centrifugal force varies as square of speed; but this force is fed back to control turbine speed through force-bar; therefore total count of turbine-revolutions during any time interval is linearly proportional to total measured flow during that same period. Gears between turbine and digital counter are selected for desired unit of flow measurement.—*The Foxboro Co., Foxboro, Mass.*

For more information circle **203** on inquiry card.

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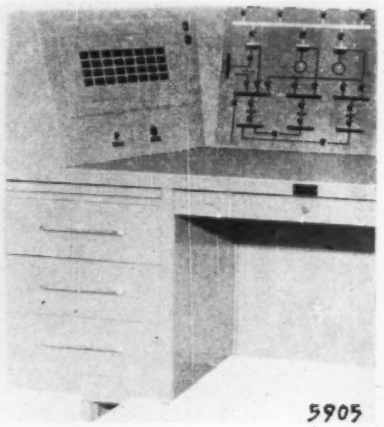
FOR FURTHER INFORMATION use the postage-free order card on page 2149

Graphic Lamp Monitor

New "Type GP" graphic panel type of lamp annunciator, designed to supervise automatic processes, flow patterns, etc., is available as: (1) non-lighted diagrams, with raised strips in various colors, with indicating



lights at desired positions; (2) using strips of translucent material, with light source behind front panel, producing a "light spot" at desired point on diagram. One of services is to have abnormal condition (of contacts under supervision) cause light unit to flash and to sound audible signal. When this signal is acknowledged by pressing a pushbutton, light remains and audible signal is silenced. Restoration of contacts to normal can remove light signal automatically, or light signal can be manually removed by operation of reset button, after normal condition is known to exist.—*H. R. Kirkland Co., Morristown, N. J.*

For more information circle **204** on inquiry card.

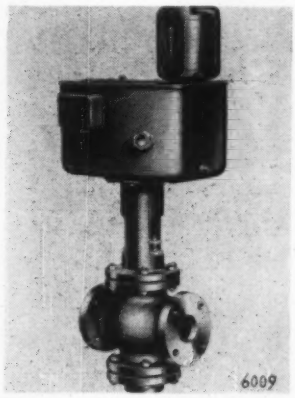
Process Pump

New "All-Chem" stainless steel positive displacement process pump is available in Type 20 Alloy and Hastelloy C for service with corrosive materials in chemical production, laboratory and pilot plant. A chemically inert Teflon-ceramic seal supplements conventional corrosion-resistant packings, and a choice of impeller materials permits selection of Neoprene, Teflon or Formica. Units are regularly fitted with two ¾" NPT ports, but can be specified with two additional ports to meet special requirements such as simultaneous feed of two dissimilar materials to obtain a mixed product. Two models, with capacity ranges to 3.5 gpm and 10 gpm respectively at 1750 rpm.—*Eco Eng'g Co., 12 New York Ave., Newark 1, N. J.*

For more information circle **205** on inquiry card.

Valve Actuator

New self-contained electro-hydraulic valve actuator permits electrical output signal of an electronic controller to be applied directly to sys-

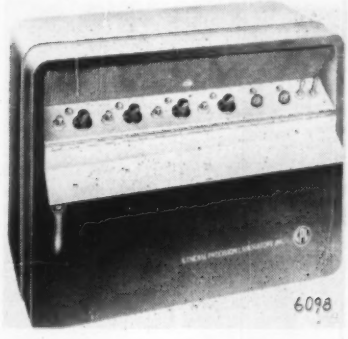


tem's final control element. It is a complete self-contained unit including control valve, hydraulic power source, and proportional positioning mechanism which can be used with existing electronic controllers. Outside connections consist of signal wires from controller and an electric power supply. Signal current is applied to a high-resistance coil (3000 ohms or more) which moves in a magnetic field. Linked to coil is maker's exclusive Jet Pipe which converts an electrical signal of less than 50 milliwatts into powerful stroke of a control valve. Valve moves at a speed of more than one inch per second. Thrusts of 600 lbs and more can be handled, with strokes presently available up to 2".—*Askania Regulator Co., 240 E. Ontario St., Chicago 11, Ill.*

For more information circle **206** on inquiry card.

Industrial TV Camera Switching Unit

New "Model PD-133" permits operation of four of maker's "PD-150" TV cameras from a single camera control

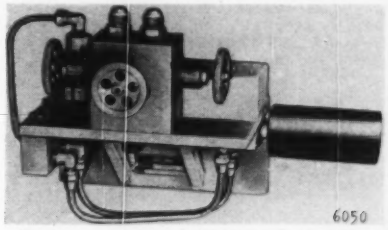


unit. Units can be cascaded to provide push-button selection of any number of cameras. With addition of sequencing means, automatic remote surveillance of a production line or process is made possible.—*General Precision Laboratory Inc., 63 Bedford Rd., Pleasantville, N. Y.*

For more information circle **207** on inquiry card.

Linear Force-balance D-p Transmitter

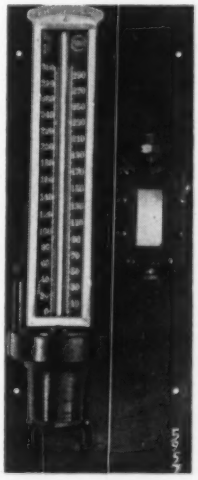
New "Delta P" fills a recognized gap in pressure instrumentation, for it is capable of pneumatically trans-



mitting measurements of exceptionally large pressure differences (to 300 psid) with static pressures to 3000 psi. Thus it is suitable for measuring pressure difference between steam header and turbine throttle or across high-pressure heat exchangers, or as a square-root flowmeter element when differential is extremely high. It is insensitive to static pressure changes. It comprises three pressure chambers, each containing a flexible bellows, all mounted on a fulcrumed beam. Two input chambers oppose each other at one end of beam, while output signal chamber at other end of beam opposes torque effect of pressure difference. No stuffing boxes or torque tubes; 3000-psi shutoff and bypass valves are built in; assembly is shock- and vibration-resistant.—*Hagan Corp., Pittsburgh 30, Penna.*

For more information circle **208** on inquiry card.

Absolute Pressure Gage



New "Princo Cat. No. 1470" is an improved model of maker's absolute pressure gage, for industrial and marine equipment employing negative pressures (turbine condensers, exhaust hoods, evaporators, etc.); is shipped ready to operate and is said to require no installation service other than mounting and connecting up to the line. Gages are individually calibrated and their readings require no further correction for barometric pressure.—*Precision Thermometer & Instrument Co., 1434 Brandywine St., Philadelphia 30, Pa.*

For more information circle **209** on inquiry card.

Pressure Switch

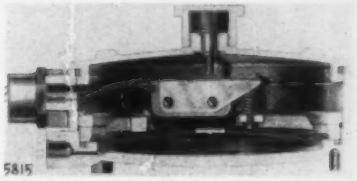
New 4-oz pressure switch can be set to actuate at hydraulic or pneumatic pressures of 100 to 12,500 psi; performs reliably under severe vibra-

tion, acceleration, and other adverse environmental conditions.—*Aircraft Controls Div., Gorn Electric Co., Inc., Stamford, Conn.*

For more information circle **210** on inquiry card.

Pressure Difference Switch

New "Diaphragm Pressure Switch 227" senses a pressure difference from 0 to 45" of water between a variable

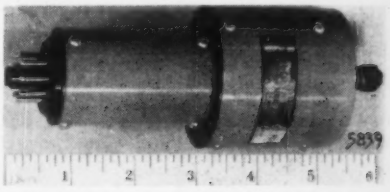


and a reference pressure, with a fixed actuation value of 0.5" of water. Reference pressure must be air or an inert gas; variable pressure can be liquid or gas. Switch can be field adjusted; is not sensitive to jarring; will operate in any position.—*Barksdale Valves, 5125 Alcoa Ave., Los Angeles 58, Calif.*

For more information circle **211** on inquiry card.

Pressure Pickup with FM Transmitter

New "Series P400 Temperature-controlled Pressure-to-Frequency Transducer" is available in absolute,

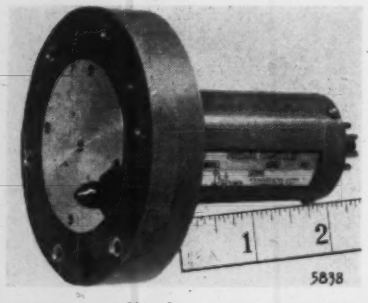


differential, or gage types for measuring pressure in non-corrosive liquids and gases. It incorporates a temperature-controlled variable-inductance pressure pickup and an FM oscillator. Variable-inductance pickup is housed in a small oven which is thermostatically controlled. Available ranges 3 to 1000 psi. Weight 10 oz.—*Datron Engg. Corp., 3613 Aviation Blvd., Manhattan Beach, Calif.*

For more information circle **212** on inquiry card.

Pressure Pickup with FM Transmitter

New "Model P512 Pressure-to-Frequency Transducer" for measuring transient pressures incorporates a variable-inductance pressure pickup and an FM oscillator. Deflection of damped diaphragm produces a proportional inductance change, which is converted to proportional frequency by FM oscillator and is supplied at



constant amplitude across output terminals. Pickup can be arranged to present a flat surface to pressure being measured. Available ranges ±5 psi. to ±2.5 psi and 0-1 psi to 0-5 psi. Weight 17 oz.—*Datron Engg, Corp., 3613 Aviation Blvd., Manhattan Beach, Calif.*

For more information circle **213** on inquiry card.

Back-pressure Controller

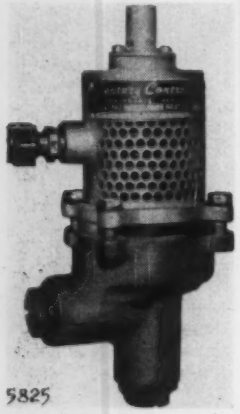
New "Micro Delta P Controller" combines pressure sensing element, control pilot and control valve; is said

to "provide square-wave pressure response, microsecond control without hunting, constant pressure throughout full flow range."—*Industrial Eng'g Corp., 525 E. Woodbine, Louisville 8, Ky.*

For more information circle **214** on inquiry card.

Pressure Regulator

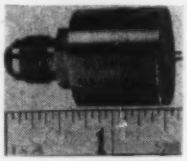
New "Absolute Pressure Regulator Valve" handles flows up to 40 cfm; maintains constant pressure at inlet



temperatures as high as 550°F; can be placed on any jet bleed line to air turbine power packs, compartment pressurization and cooling systems, or fuel tank pressurization and relief systems.—*Century Controls Corp., Farmingdale, L.I., N.Y.*

For more information circle **215** on inquiry card.

Pressure Pickup

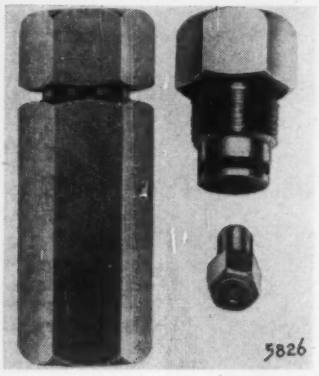


New "Model S-6" is a single-coil diaphragm-type variable-inductance unit, for use either as variable inductor of inductance-controlled FM/FM sub-carrier oscillators or for voltage-controlled oscillators and bridge circuits. Depending on the application, it is constructed so that curves of pressure vs. frequency, pressure vs. inductance or pressure vs. voltage will be linear. It can also be made non-linear to match a predetermined curve. Acceleration sensitivity is 0.01%/G or less; rise time to a step pressure pulse is about 50 usec. Standard ranges from 1 to 500 psig, psia or psid.—*Ultradyne Engineering Labs., Inc., P. O. Box 8007, Albuquerque, N. M.*

For more information circle **216** on inquiry card.

High-pressure Snubber

New snubber for use on systems working as high as 60,000 psi utilizes discs of corrosion-resistant porous

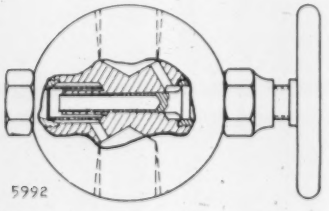


stainless steel for protection of pressure instruments against line surges and pulsations.—*Chemiquip Co., 460 West Broadway, New York 12, N. Y.*

For more information circle **217** on inquiry card.

Pressure Snubber

New "VP Adjustable Type Pressure Gauge Snubber" utilizes pulsations of operating pressure to help



damp pulsating pressure. Long hollow-piston-type damping plug has thin walls which flex slightly during each pulsating pressure cycle; is adjustable and has a slight taper which fits into a matching taper in body. For any given application, required restriction is established. Snubber comes with a stainless steel filter; is available in ¼" and ½" sizes. Operating pressure rating is 6,000 psi.—*Velotrol Corp., 428 W. 8th St., Bartlesville, Okla.*

For more information circle **218** on inquiry card.

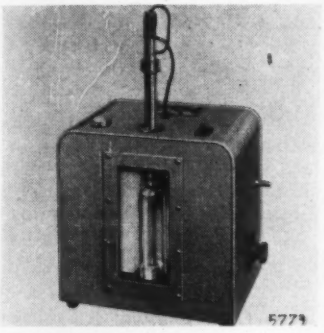
Pulsation Damper for Pipe Lines

New "Desurger" is said to be "totally unlike any apparatus offered previously to protect instruments, valves, fittings, pipes, and the like from dangerous pressure surges and pulsation. . . .is at least twice as effective and only one-sixth the size of any of the older devices produced for removing pulsations." Heart of device is a rubber sleeve which works with throttling orifices that circle main flow line. With air pressure, sleeve rests close to throttling orifices; during surges, excess pressures are dissipated by forcing liquid through orifices and distending sleeve against a precharge of air.—*Westinghouse Air Brake Co., Wilmerding, Pa.*

For more information circle **219** on inquiry card.

Vacuum Controller

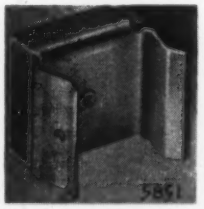
Newly redesigned "Micro-Set" manostat provides, at no increase in price, more accurate control of vacuums be-



tween atmospheric and 2 mm abs. pressure. Control sensitivity better than 0.05 mm. New "Micro-Set" maintains its setting even when system is shut down overnight.—*Precision Scientific Co., 3737 W. Cortland St., Chicago 47, Ill.*

For more information circle **220** on inquiry card.

Magnetic Mounting Clips for Draft Gages, etc.



New "Magneclips" obviate need for an accessible flat surface on which to place portable draft gages; thereby make a one-man job out of taking draft or pressure readings in hard-to-reach places. A "magneclipped" gage clings to any steel surface, grips securely (15 lb test-proved) and can be adjusted easily to level setting that won't vibrate out of position.—*Dep't IA, F. W. Dwyer Mfg. Co., P. O. Box 373, Michigan City, Indiana.*

For more information circle **221** on inquiry card.

TEMPERATURE and HUMIDITY

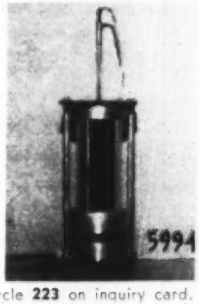
High-speed Thermistors

New "Optitherm Infrared Detectors" are small thermistors that can "sense infrared radiation in as little as 2 milliseconds . . . also rugged, stable and long-lived." Sensitive elements are 10-micron-thick (0.0004") rectangular flakes with sides that can be varied from 0.1 to 10.0 mm. (Area determines field of view when used in an optical system). Two thermistor flakes are normally in each detector assembly: one is a matched, shielded compensating element that minimizes effects of ambient temperature changes. "Optitherms" are available with standard silver chloride or KRS-5 windows, or with special windows on order; housings are hermetically sealed and do not require a vacuum.—*Barnes Engineering Co., 30 Commerce Road, Stamford, Conn.*

For more information circle **222** on inquiry card.

Vacuum-insulated Temperature Standards

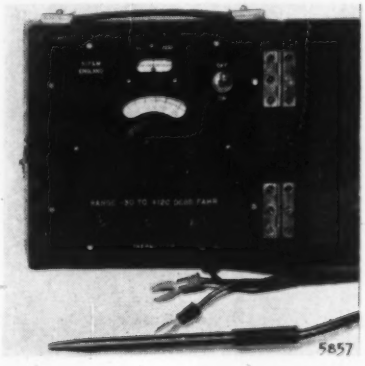
New temperature standards feature long dwell (several minutes) at melting point. Calibration of thermometers, thermocouples, etc., to 0.01° is commonplace; 0.001° is possible. Sodium, tin and zinc are available in glass Dewar flasks; aluminum, eutectic No. 2, and silver in quartz.—*Weiller Instruments Corp., 2 Stone St., New York 4, N. Y.*



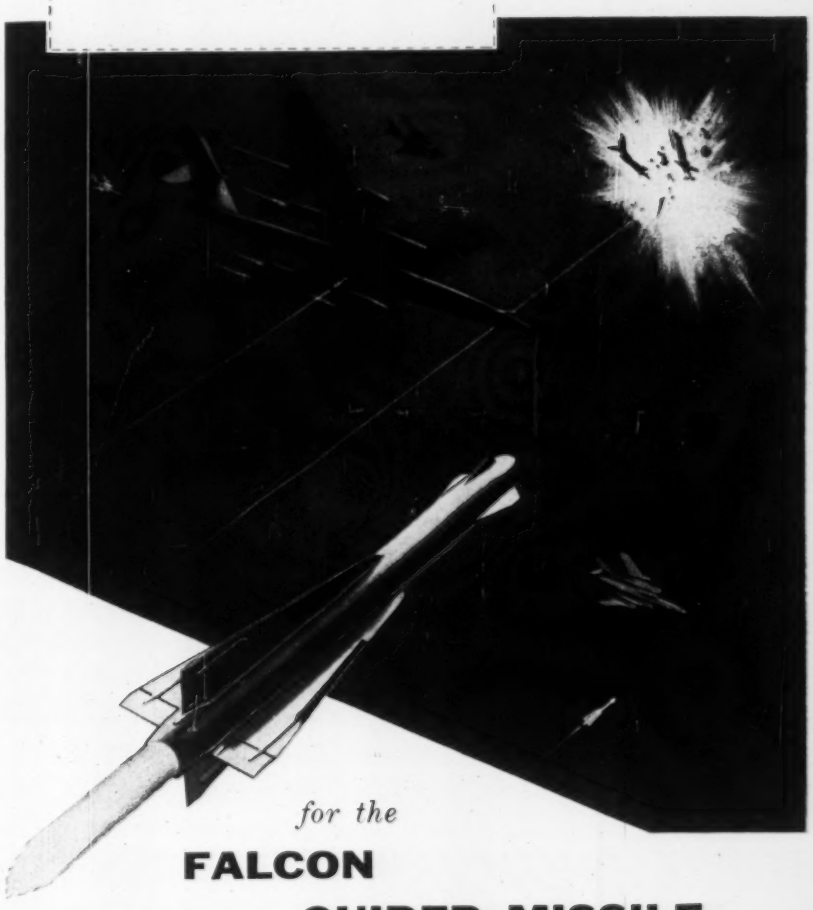
For more information circle **223** on inquiry card.

Resistance Thermometer

New "Thermaster" (made in England) features: (1) full-scale ranges as short as 10 C° or 20 F° between limits of −80°C and 200°C or F equivalents; (2) rapid-response thermal elements in various forms for in-



CIRCUIT DESIGN ENGINEERS



for the

FALCON GUIDED MISSILE

So accurate and deadly is the Hughes Falcon guided missile produced in Tucson, Arizona, for the U.S. Air Force, that it has knocked maneuvering drone bombers out of the air even without an explosive warhead. Although its electronic brain can outwit any enemy bomber, it is the smallest guided missile in production.

Because of this small size and consequent extreme miniaturized packaging, new production techniques have had to be conceived. This leads to production testing of individual parts, small integrated units, self-contained components, complete integrated systems, and simulated environmental performance.

The development of equipment for producing and testing of such a missile provides a continuous challenge to engineers experienced in electronic circuit design including the following:

Pulse—Power Supply—Transistor—IF and RF—Clamping—Wave Shaping—Switching—Phase Shift—Input-Output—Modulator—Discriminator—Feedback—Video Circuits.

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ENGINEERING STAFF RELATIONS

HUGHES

Aircraft Company

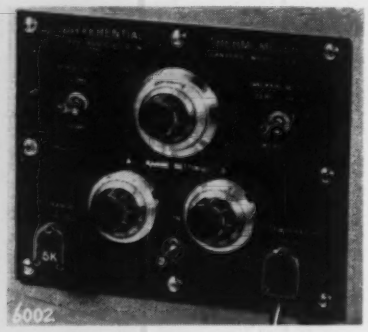
Tucson, Arizona

dustry, hospitals, etc.; (3) speedy operation by rotating one dial until galvanometer shows balance, and reading calibrated scale: usually a few seconds; (4) operation from a small dry battery.—*Epic Inc.*, 154 *Nassau St., New York* 38, *N. Y.*

For more information circle **224** on inquiry card.

Differential Thermometer

New "Fiske Differential Thermometer" measures temperature differences between a reference and vari-

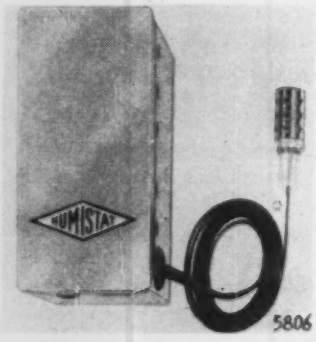


able, or between two variables, also calorimetric temperatures, to a precision of 0.001C° in range of —50 to 200°C. It comes in either one-element model to measures difference from a fixed reference, or two-detector system used for variables or for sliding differences. Extremely small (0.2-ml) samples can be checked or monitored. Output can be remotely recorded. Ranges are selected by plug-in resistors and variable voltage-dividing resistors.—*Advanced Instruments, Inc., Needham* 92, *Mass.*

For more information circle **225** on inquiry card.

Humidity Controller

New "Humistat," said to make available "for the first time a small low-priced electric hygrometer humid-

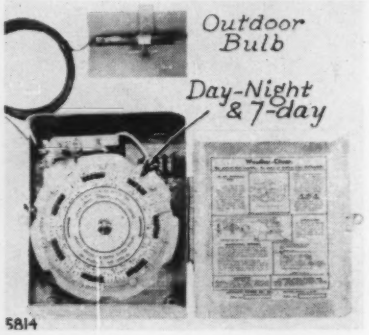


ity controller," operates humidifiers, dehumidifiers, and air conditioners to maintain humidity control within 1.25% relative humidity; covers RH range of 5% to 95% by individual sensing elements with operating ranges of about 15% RH. Settings within each element range are made in a few seconds; a calibrating resistor is plugged in and a knob is turned until a click is heard. Accessories include various sensing element mountings.—*American Instrument Co., Inc., Silver Spring, Md.*

For more information circle **226** on inquiry card.

Weather-actuated Time Switch for Heating Systems

New "Weather-Chron" stops heat input to building when outdoor temperature rises above adjustable pre-

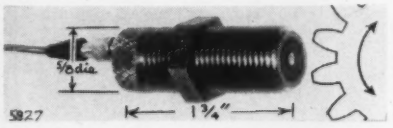


selected minimum; eliminates night setback when outdoor temperature drops below adjustable preselected minimum; adjusts hours of heating in accordance with building occupancy needs for each day of week.—*Automatic Devices Co., Inc., Western Springs, Illinois.*

For more information circle **227** on inquiry card.

Magnetic Pickup

New "Model 50 A" generates an output voltage proportional in amplitude and frequency to velocity of



magnetic material moving near its sensitive end; can be used with commercially-available counters to measure, count, or detect motion, vibration, or speed; withstands extreme shock, vibration, and temperatures to 500°F.—*Minatron Corp., Belle Mead* 3, *N. J.*

For more information circle **228** on inquiry card.

Magnetic Pickups

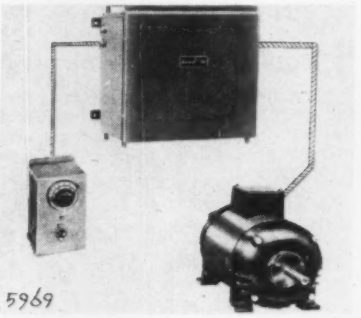
New "Model 3030 Magnetic Pickup" is an ultrasensitive modification of maker's standard "Model 3010-A," for

use in slow-speed or low-excitation ranges. Construction is identical to that of standard "3010-A" except that many more turns of considerably smaller wire are used. ★New "Model 3030-HTAN," also highly sensitive, is for use at temperatures to 500°F.—*Electro Products Labs.*, 4505 *N. Ravenswood Ave., Chicago* 40, *Ill.*

For more information circle **229** on inquiry card.

Adjustable-speed Drives

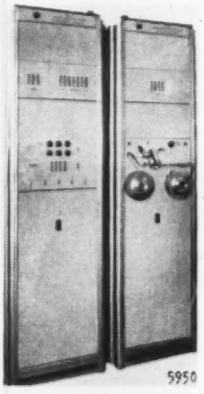
New "100 Series" adjustable-speed drives are said to "offer features not heretofore available in conventional



electronic drives." They permit precise adjustment over a 100:1 speed range. Any setting can be repeated and held to better than 0.5% of full rated speed in spite of wide changes in line voltage, temperature, or torque load. Both ¼ and ½ hp models are available, either of which can be adjusted for any speed between 36 and 3600 rpm.—*Servo-Tek Products Co., Inc.*, 1086 *Goffle Rd., Hawthorne, N.J.*

For more information circle **230** on inquiry card.

Ballistic Chronograph

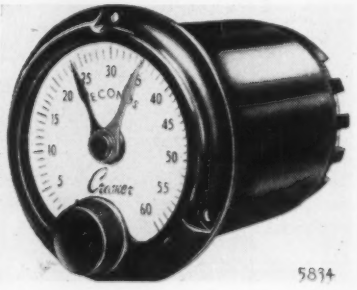


New "Automatic Chronograph" measures velocity of bullets fired from rapid-fire machine guns. It measures number of rounds fired per minute and individual velocities of all rounds. Two photoelectric detector screens are spaced close enough together that no two rounds are in between them at the same instant of time. From 10 to 9000 rounds per minute can be measured. Data recorder chronograph operates from start and stop pulses. If no stop pulse is received (bullet missing second screen) no velocity measurement is recorded but a round print is made upon paper tape for inclusion in rate-of-fire data.—*Potter Instrument Co., Inc.*, 115 *Cutter Mill Rd., Great Neck, N. Y.*

For more information circle **231** on inquiry card.

Time Delay Relay

New "Type 412" synchronous motor-driven time delay relay is said to incorporate many desirable new fea-



48 hours instead of 45 days!

Process monitoring and control

Chemical analysis

Dynamic and static testing

Two of four identical 50-channel units comprising system

Here's a true story of how data-handling automation can save real dollars. The data-handling system shown, right, was installed by Convair's Ft. Worth, Texas, division. In just two weeks... during a single series of pressure measurements . . . Convair saved a substantial portion *of the entire system cost!* The saving in time was even more impressive. Tabulated test data reached design engineers just 48 HOURS after the wind-tunnel tests, a striking contrast to the 45 days previously required for reducing hundreds of manometer-tube photographs.

Perhaps wind-tunnel data reduction isn't of particular interest to you. But whatever your problem, if it involves *data*, it will pay you to learn how CEC *systems engineering* can make the handling of that data more accurate, faster, less expensive. Send today for Bulletin CEC 1304-X22.

Specifically, this is what the custom-designed Convair data-processing system does once the "start" switch is pressed . . .

. . . Automatically measures, digitizes and records output from 200 pressure pickups.

. . . Reads out digital pressure values at a rate of 200 points in 2-minute period.

. . . Operates at an overall system accuracy of 0.75% of full-scale pressure, including errors in transducers.

. . . Automatically compensates for residual bridge unbalance in each of the 200 channels.

. . . Controls calibration factor on all channels independently.

. . . Punches out on paper tape and tabulates in numerical typewritten format the results of all 200 pressure measurements.

Systems Division

Consolidated Engineering Corporation

ELECTRONIC INSTRUMENTS FOR MEASUREMENT AND CONTROL

300 N. Sierra Madre Villa, Pasadena 15, Calif.

Sales and Service Offices Located in: Albuquerque, Atlanta, Boston, Buffalo, Chicago, Dallas, Detroit, New York, Pasadena, Philadelphia, San Francisco, Seattle, Washington, D. C.

For more information circle **45** on inquiry card.

tures; is interchangeable with its predecessor, "Type 410" (or TEC). Setting mechanism provides quick adjustability over full dial range, even while timer is operating. Many external load connection possibilities without affecting internal wiring; further flexibility through different internal contact arrangements. Contacts rated 15 amps at 125 vac. Accuracy (exclusive of human setting error) is within 0.5% of full scale. Available in 14 time ranges from 6 sec through 24 h; 115 and 200 v, 25, 50 and 60 cps. Electrical and mechanical life in excess of one million operations.—*The R. W. Cramer Co., Inc., Centerbrook, Conn.*

For more information circle **232** on inquiry card.

COMPUTING and DATA-HANDLING

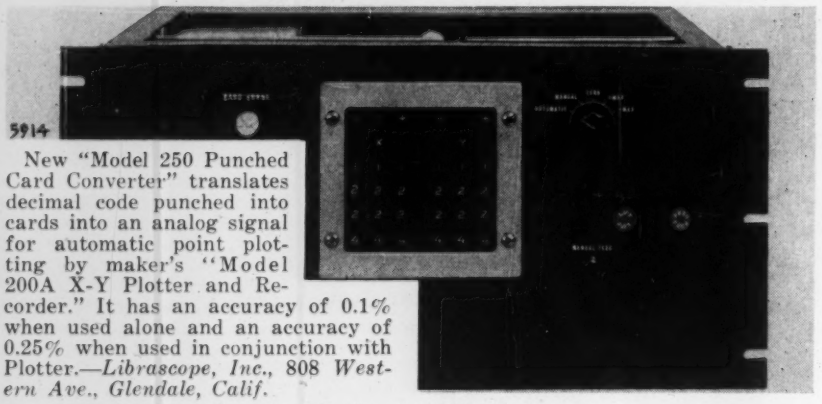
Analog-to-digital Converter

New "Rea-Converter" high-speed analog-to-digital converter with capacity of up to 100,000 conversions per second, 30-mv resolution and 0.1% guaranteed accuracy, will accept signals from pickups, FM discriminators, FM or PWM magnetic tapes, film readers, etc., and convert

them to any desired digital code. Used with appropriate commutating, it will sequentially sample data from many sources. Digital output can be printed out or used as input to a digital computer. Interim storage of digital data can be accomplished, if desired, by a programmed magnetic tape unit.—*J. B. Rea Co., Inc., 1723 Cloverfield Blvd., Santa Monica, Calif.*

For more information circle **233** on inquiry card.

Card Data Converter for X-Y Plotters



New "Model 250 Punched Card Converter" translates decimal code punched into cards into an analog signal for automatic point plotting by maker's "Model 200A X-Y Plotter and Recorder." It has an accuracy of 0.1% when used alone and an accuracy of 0.25% when used in conjunction with Plotter.—*Librascope, Inc., 808 Western Ave., Glendale, Calif.*

For more information circle **234** on inquiry card.

Computer Delay Lines

New custom-built hermetically-sealed totally-encapsulated lumped-constant delay lines are designed specifically for use in computing circuits of digital computers. Wide choice of impedance levels and delays. Photo shows No. 11-12. Thermal stability: average delay change of 0.00005 usec per usec per C deg; extremely low signal attenuation; low cross talk in minimum space. Extended bandwidth for long delay lines affords fast pulse rise time; phase shifts essentially linear.—*ESC Corp., 534 Bergen Blvd., Palisades Park, N. J.*

For more information circle **235** on inquiry card.

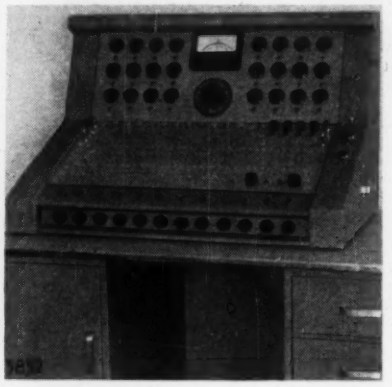
Slant Range Computer

New "SRGX-1" is said to solve the three-dimensional slant-range triangle problem more accurately than any available non-digital unit. Accuracy is 0.01% for most common conditions. Feature is thermostat control of matched low-temperature-coefficient components.—*Julie Research Labs., Inc., 341 E. 149th St., Bronx 51, N. Y.*

For more information circle **236** on inquiry card.

Analog Computer

New portable desk model electronic analog computer having 12 high-gain operational amplifiers and sufficient



accessories (resistors, capacitors, diodes, and plugs) to utilize its full capacity, is said to be "in the low-to-medium price category." Among claimed advantages: portability (two one-man packages), low total amplifier drift, extremely simple plugboard (can be learned in minutes), ability to solve non-linear problems, and independence of all auxiliary equipment including recording amplifiers.—*Control Specialists, Inc., 115 E. Arbor Vitae St., Inglewood 1, Calif.*

For more information circle **237** on inquiry card.

Computer Voltmeter

New "Digi-Volt" for dc analog computers, available in 3-digit and 4-digit models, is said to be "ideal for

reading out computer setting up to scaling pots," features speed of 15,000 counts per minute and instantaneous-polarity detection (whence an average of about two seconds for a reading). Power requirements 25 watts 115-v 60 cps; reference voltage plus and minus 100 vdc at 2 ma.—*Feedback Controls, Inc., 1332 N. Henry St., Alexandria, Va.*

For more information circle **238** on inquiry card.

Key Punch Adder System

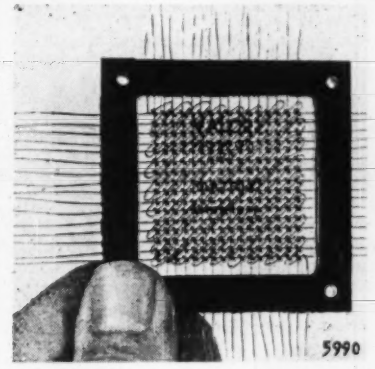
New "Model 611-024" attachment cables together a Monroe ten-key adding machine and IBM key punch Models 024, 026, 031, and 016 to give immediate proof totals over keypunching; causes numbers entered in adding machine to be automatically key-

punched into cards. Associated indicative information is entered on the non-add, appearing in cards and on adder's total.—*Systematics, Inc., Hermosa Beach, Calif.*

For more information circle **239** on inquiry card.

Magnetic-storage Matrix Units and Kits

New line of components for magnetic storage system mock-ups represents a heretofore non-existent source



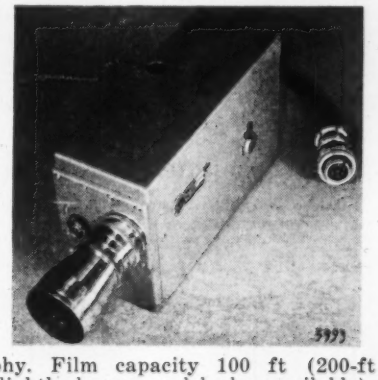
to development engineer: a complete set of all of magnetic elements including driver transformers, matrix switches, and actual matrices which allow engineer to mock up several different circuit arrangements for evaluation of their applicability. Photo shows one of maker's magnetic memory matrices.—*Valor Electronic Components Co.*, 5808 *Marilyn Ave., Culvert City, Calif.*

For more information circle **240** on inquiry card.

PHOTOGRAPHY, OPTICS, etc.

High-speed Photographic Recorder

New 16-mm "VDR-5" is designed for aircraft, missiles or other applications requiring high-speed photogra-



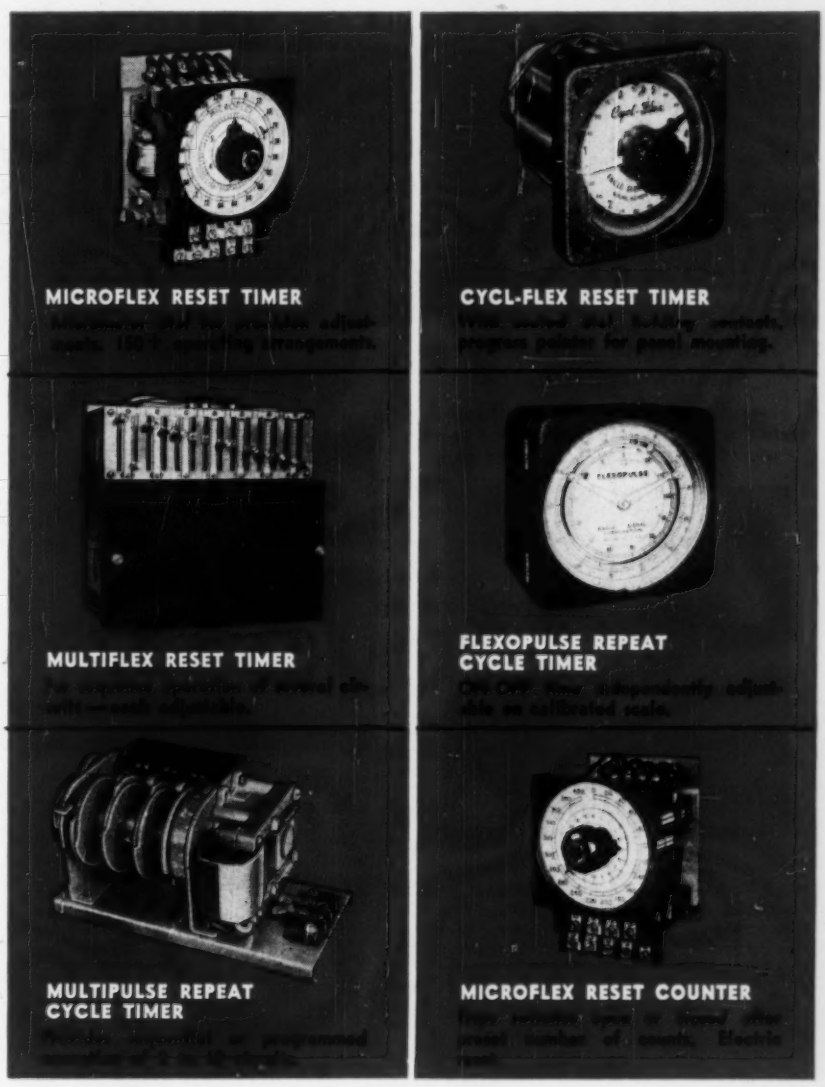
phy. Film capacity 100 ft (200-ft slightly larger model also available). Frame rate 66 to 200 per second.—*Vought Company, P. O. Box* 1350, *Beverly Hills, Calif.*

For more information circle **241** on inquiry card.

Portable Photocopy Unit

New portable (12½-lb) unit which exposes clear, permanent copies of almost any type of written or printed

EAGLE
Timers and Counters
VITAL COMPONENTS IN MODERN AUTOMATION



Represented above are but a few of the complete line of popular EAGLE Industrial Timers and Counters.

Models are available in a wide range of modifications to fit your particular application. Modern compact design and precise construction of these EAGLE components has won them an enviable coast-to-coast reputation for accuracy and long service-free life of operation. Write us about your needs.

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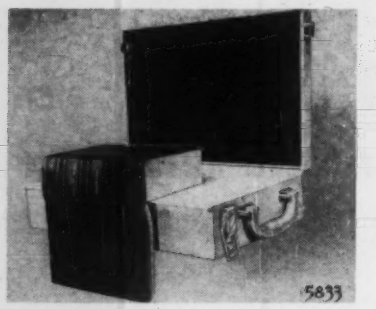
For more information circle **47** on inquiry card.



material fits into a briefcase; has 9½" by 14¾" copying surface. Storage compartment protects exposed negatives until they can be developed. Unit operates on either ac or dc.—*Copease Corp.*, 270 *Park Ave., New York* 17, *N. Y.*

For more information circle **242** on inquiry card.

Illumination Device for Shadow-free Photos

New "Type B Hinelight," through use of a graded circumferential tube light arrangement which places camera lens inside light source, minimizes shadow in complex electronic and mechanical assemblies. Personal variables are eliminated, results being identically reproducible. In many cases no need for retouching. Applications include industrial and educational TV, remote-control photography of hazardous reactions or operations, and progress photography of prototype equipment for records.—*Hinelight Corp.*, 2500 *John St., Fort Wayne, Indiana.*

For more information circle **243** on inquiry card.

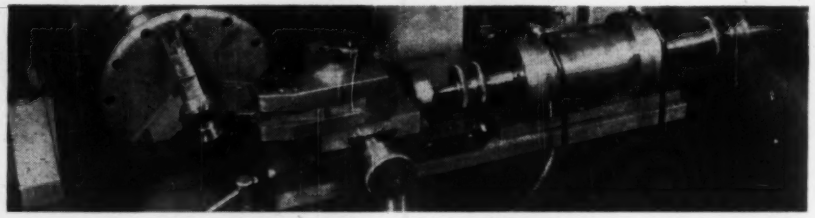
Lens Tester Independent of Human Vision

New electronic instrument is said to be the first to enable optical scientists to evaluate and grade the performance quality of lenses in objective mathematical terms; is described as "a major advance in the optical sciences, will introduce unprecedented accuracy, speed, and economy in prerating lenses of all types, and will enable users to select by specific grade lenses with exact characteristics for given applications."—*Radio Corp. of America*, 30 *Rockefeller Plaza, New York* 20, *N. Y.*

For more information circle **244** on inquiry card.

SHOP EQUIPMENT, AUTOMATION

Facing Attachment

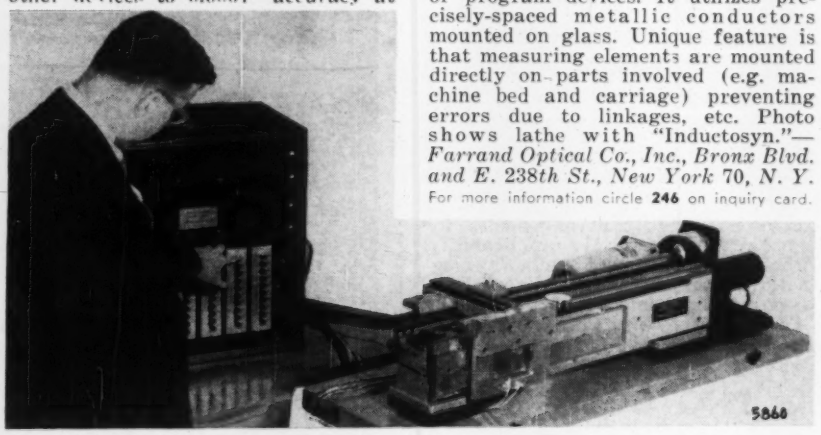


New automatic hydraulic facing unit makes it possible for any boring machine to simultaneously face as well as bore ferrous and non-ferrous materials; assures precise perpendicularity of face to bore. Standard capacity 6" diam.—*Belock Instrument Corp., College Point, Queens, N. Y.*

For more information circle **245** on inquiry card.

Machine-tool Carriage Micropositioner

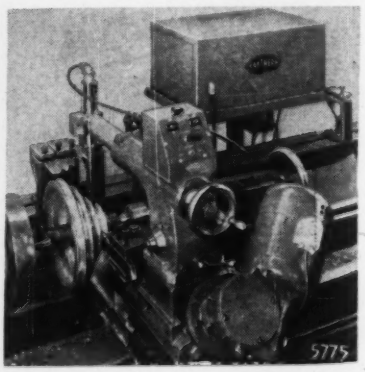
New "Linear Inductosyn" will position machine-tool carriages and other devices to 0.0001" accuracy at command of punched cards or tapes, keyboard (illustrated), dial settings or program devices. It utilizes precisely-spaced metallic conductors mounted on glass. Unique feature is that measuring elements are mounted directly on parts involved (e.g. machine bed and carriage) preventing errors due to linkages, etc. Photo shows lathe with "Inductosyn."—*Farrand Optical Co., Inc., Bronx Blvd. and E. 238th St., New York* 70, *N. Y.*



For more information circle **246** on inquiry card.

Machine-tool Controllers

New automatic contour and depth of cut controllers are designed for installation on either new or existing shop machines and allow for normal manual operation when needed. Precision is limited only by mechanical condition of machine tool. Tolerances of 0.0015" can be maintained even on abrupt changes of contour. Duplicators are available as single, dual or two-motion servo-controls, automatic in operation along one or two axes up to 360° as dictated by contour of templet.—*Raytheon Mfg. Co., Waltham* 54, *Mass.*



For more information circle **247** on inquiry card.

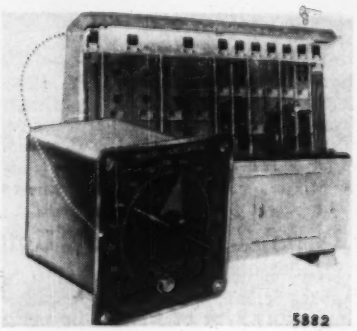
Micro Drills

New left-hand and center drills in line of "Sphinx" micro drills. Availability of left-hand drills will interest users of automatic screw machines, particularly Swiss type. "Spirec" center drills are extremely rigid and will produce true starting holes. Available up to 3.00 mm (0.1181").—*Louis Levin & Son, Inc.*, 3610 *S. Broadway, Los Angeles* 7, *Calif.*

For more information circle **248** on inquiry card.

Preset Counter for Tools

New "Count Switch" is set to number of operations at which experience indicates a tool should be changed; after this number of electrical im-

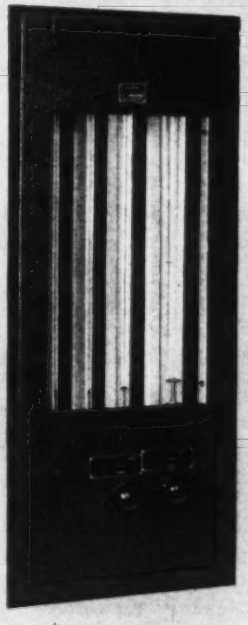


Holds No Terror at CRL

TYPE II VISCOMETER

A new laboratory-field instrument, using advanced flow system design, which quickly indicates kinematic viscosity of fuels, oils, weak acids and other base solutions. Two ranges available: .5 to 5.0 and 3.0 to 30 centistokes. Readability: within 1%. Portable or panel mounted.

COX INSTRUMENTS *prove this day-in-and-out* IN THE LABORATORY . . ON PRODUCTION LINES



Forty-three years ago, Commercial Research Laboratories produced the *first* precision Cox instruments — far advanced for their day. The name Cox has since become synonymous with accuracy and reliability wherever testing devices are used. So much so, in fact, that scores of aircraft, automotive, and hydraulic equipment manufacturers — here and abroad — have made a common practice of *calling in CRL first* — for expert advice in the design, development and manufacture of *any* hydraulic or air flow measuring device, large or small.

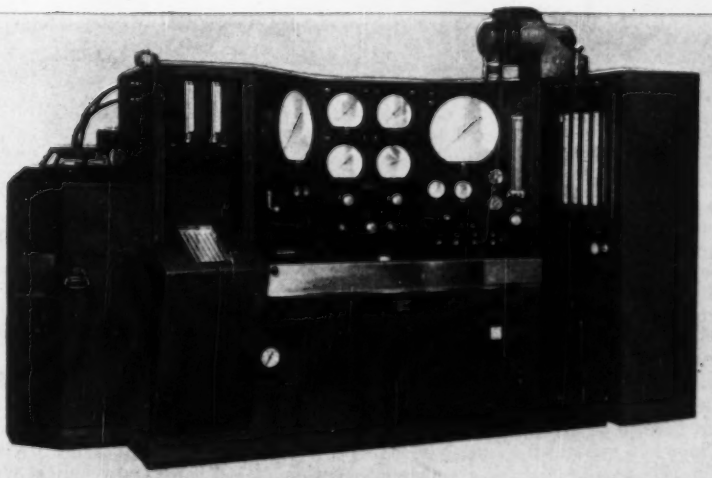
If your own requirements call for the smallest production-model flowmeter, or the most intricate, complete test stand — call in CRL first. Save time—and get dependability *plus* accuracy.

TYPE 12 FLOWMETER

Available in three series — 40, 90, 100 — Cox Type 12 Flowmeters combine high precision performance, outstanding readability, and unusually low cost. All Cox Flowmeters — including the Single Stage Type 8, the automotive Type 10, and the Type 14 for pressures up to 1000 p.s.i. — feature patented "Inner Wall" guides which permit individual matching of tube and float for optimum results.

TYPE 416 UNIVERSAL FUEL NOZZLE TEST STAND

A complete testing "laboratory" designed and built by CRL for determining optimum efficiency of jet airplane fuel nozzles. Now in use by the U.S. Air Force and others. Other CRL products include Cox Calibrating Stands, Carburetor Flow Stands, Magnetic Thickness Gages, Balanced Electronic and Vibration Recording Equipment.



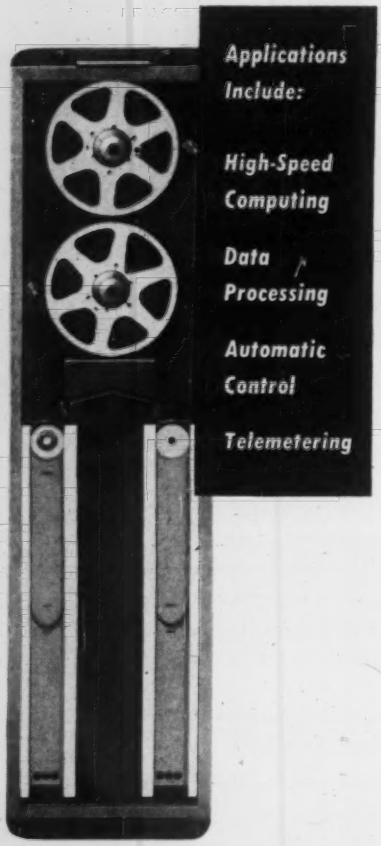
C R L

For more information circle **49** on inquiry card.

DataReader

Model 546

A transport unit for high speed searching, reading and recording of data on magnetic tape.



PERFORMANCE:

RAPID START—STOP—REVERSE—from stop to full speed in 6 milliseconds.

HIGH TAPE SPEED—optional single speed of 30, 40, 50, 60 or 75 in/sec.

TWO-DIRECTION SEARCH—either direction, automatically at full speed.

REMOTE OPERATION—forward, reverse, stop, rewind and selection of reading and writing.

VACUUM COLUMN TAPE CONTROL—provides strain-free tape feed over entire length of tape.

END-OF-TAPE SENSING—stops automatically at either end of tape.

RAPID REWIND—2400 ft. of ½" or ¾" tape in 3 minutes.

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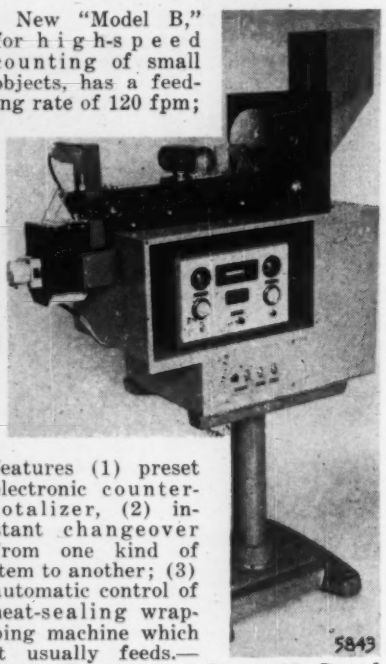
For more information circle **50** on inquiry card.

pulses it shuts down machine. Thus, tool wear never reaches point where tools must be ground excessively to resharpen.—*Hagen Mfg. Co., Moline, Illinois.*

For more information circle **249** on inquiry card.

Counting Machine

New "Model B," for high-speed counting of small objects, has a feeding rate of 120 fpm;

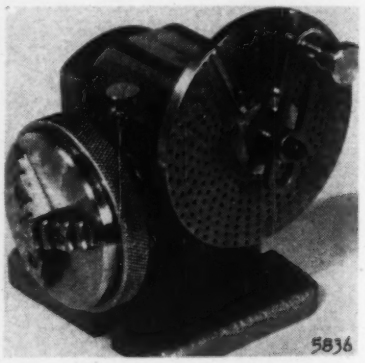


features (1) preset electronic counter-totalizer, (2) instant changeover from one kind of item to another; (3) automatic control of heat-sealing wrapping machine which it usually feeds.—*Delta Engineering Corp., 88 Broad St., Boston, Mass.*

For more information circle **250** on inquiry card.

Dividing Head

New "Model CS-65" can be used on equipment used for light machining, layout work, engraving, etc.; has 40:1

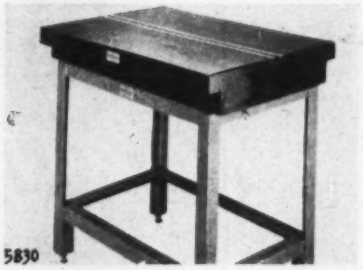


ratio crank indexing. Standard equipment: dog face plate; indexing plate with adjustable sector arms; Allen wrench; 3-jaw universal chuck with 2½" internal or external capacity reversible jaws: cutboard center.—*Custom Scientific Instruments, Inc., 541 Devon St., Kearney, N. J.*

For more information circle **251** on inquiry card.

Black Granite T-slotted Surface Plates

New type of black granite surface plate has an inserted T-slot, fabricated from mild steel, for jobs where

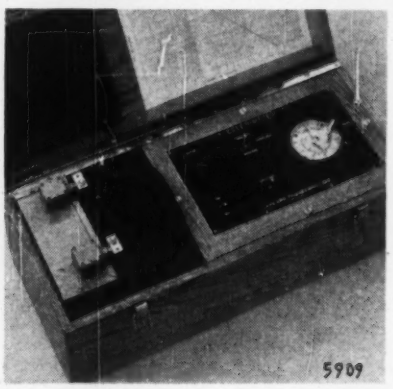


jigs, fixtures, and precision instrument applications are used; is available with no clamping ledges or two clamping ledges parallel to T-slot. Sizes up to 72" x 144"; accuracies to 50 microinches per inch.—*Collins Microflat Co., Inc., 2326 E. 8th St., Los Angeles 21, Calif.*

For more information circle **252** on inquiry card.

Machine-speed Indicator

New "Celerimeter" for measuring straight-line speeds of moving sections of fixed machinery and equip-

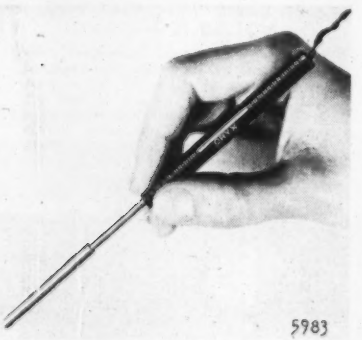


ment. Range: 5 to 30,000 ipm; synchronous-motor indicator measures 0.01-sec intervals. Among applications: determination of proper shot plunger speed on a die-casting machine; pressure build-up time, compression period, complete cycle time, conveyor speed.—*Lake Erie Eng'g Corp., Box 68, Kenmore Station, Buffalo 17, N. Y.*

For more information circle **253** on inquiry card.

Miniature Soldering Tool

New "Oryx Model 11" weighs less than ½oz; is 6" long; takes a minute to heat; has a 5/32" pure nickel



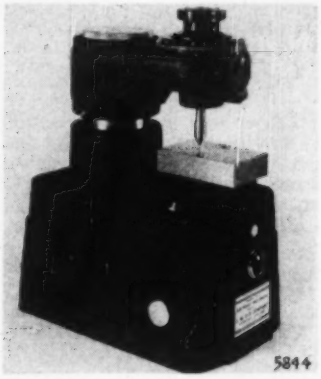
non-corrosive tip which can be replaced if necessary.—*Television Accessories Co., 1412 Great Northern Bldg., Chicago 4, Ill.*

For more information circle **254** on inquiry card.

DIMENSIONAL GAGING, etc.

Motorized Micrometer

New "Model H Carson-Dice Motor-driven Electronically-controlled Micrometer" yields direct measurements

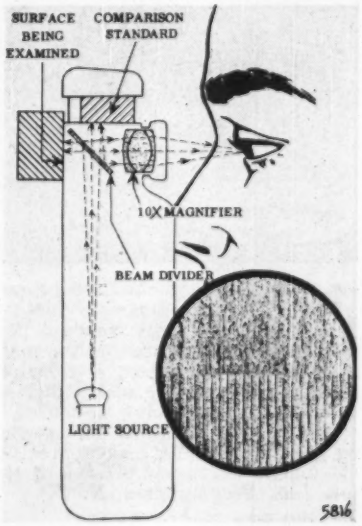


accurate to 0.00005" or better, independent of any human variable in sensing contact or setting the dial; is a true screw-thread-principle measuring instrument and not a comparator. Dimensions of any electrically-conductive part are read directly on a 3" dial. Operation is automatic: after placing work on anvil, operator presses a button and motor brings micrometer to precise point of contact with work at a speed several times that of best operator. At instant a setting is completed a green light glows. Micrometer being stopped before any pressure is exerted on work, measurements can be made on fragile or flexible parts with same speed and precision as for rigid parts. Maximum error less than 0.0001" at 3" maximum range and no more than 0.00005" for measurements under 0.25". Repeatability 0.00002" at any reading.—*J. W. Dice Co., Englewood, N. J.*

For more information circle **255** on inquiry card.

Optical Comparator for Surface Roughness

New optical comparator enables operator to see work to be examined and a standard surface roughness scale,



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American A-88 standard mercury type orifice meters for working pressures to 5000 psi. in interchangeable 10, 20, 50, 100 and 200-inch ranges give you complete versatility to meet any flow measurement requirement. Integrating instruments integrate both static and differential pressures giving totalized flow indications and telemetering equipped instruments transmit integrated indications to remote locations.

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Write for full details now.

AMERICAN-WESTCOTT MERCURY MANOMETERS GIVE YOU ALL THESE ADVANCED DESIGN FEATURES . . . . . .

- Minimum Simple Maintenance—easy access to float lever arm during calibration.
- Highest Accuracy—inherent straight line calibration.
- Interchangeable Ranges—no manifold piping changes.
- Pressure-Tight Teflon-Packed Stuffing Box—nearly frictionless, free from maintenance troubles, never needs lubrication.
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- Dependable Performance—improved check valves give positive shut-off for over-range protection.

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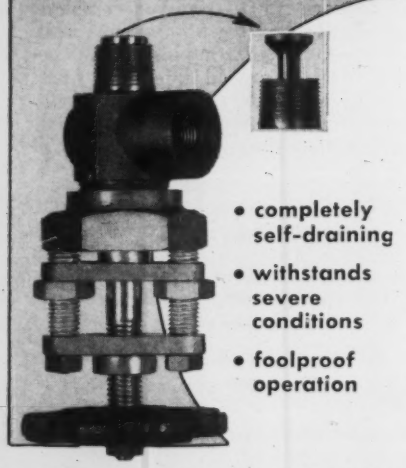
For more information circle **51** on inquiry card.

New!

Jerguson Drain or Sampling Valve



- completely self-draining
- withstands severe conditions
- foolproof operation

The new Jerguson No. 23 Drain or Sampling Valve is completely self draining, for the valve stem seats on the outside of the valve body. It is ideal for installations where it is desirable to have the valve seat inside the wall of a vessel in order to prevent the typical condition of liquid remaining in the nipple and valve inlet.

This rugged, new Jerguson Valve has outside screw and yoke construction to meet high temperature or corrosive conditions where inside threads cannot be tolerated. The efficient outside thread design eliminates possible freezing and allows the valve stem to work freely at all times. The No. 23 Valve provides foolproof operation because the stem is constructed with a left-hand thread, thus allowing the valve handle to operate in the normal direction of standard valves.

The No. 23 is recommended for pressures up to 4000 lbs. @ 100° F. or 1000 lbs. @ 750° F. Standard with ¾" N.P.T. Male inlet and ¾" N.P.T. Female outlet. Optional features include construction with an additional connection for such uses as a steaming out line, or with a reamer on the end of the stem to break away encrusted matter which may have collected on the inside vessel wall.

Write for data unit and complete details.

JERGUSON

Gages and Valves for the Observation of Liquids and Levels

JERGUSON GAGE & VALVE COMPANY

100 Fellsway, Somerville 45, Mass.

Offices in Major Cities

Jerguson Tress Gage & Valve Co., Ltd., London, Eng.
Pétrole Service, Paris, France

For more information circle **52** on inquiry card.

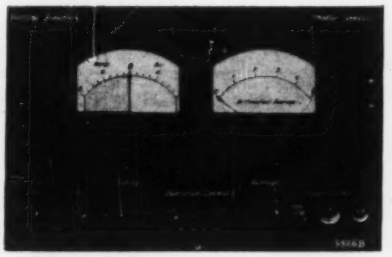
NEW INSTRUMENTS

both in field of view under 10 power magnification. Illuminating system emphasizes surface irregularities under identical conditions.—*Bausch & Lomb Optical Co., 635 St. Paul St., Rochester, N. Y.*

For more information circle **256** on inquiry card.

Profile Recorder

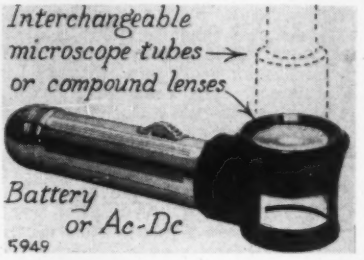
New "Proficorder" provides a magnified chart record of the profile of internal and external machined and finished surfaces. It records (1) waviness, bows, steps and other widely-spaced irregularities, with surface roughness omitted, (2) roughness irregularities alone, with waviness omitted, or (3) combined roughness and waviness profile. Selection is made by push buttons. In addition, average height of roughness profile being recorded is indicated continuously.—*Micrometrical Development Corp., 2821 S. State St., Ann Arbor, Mich.*



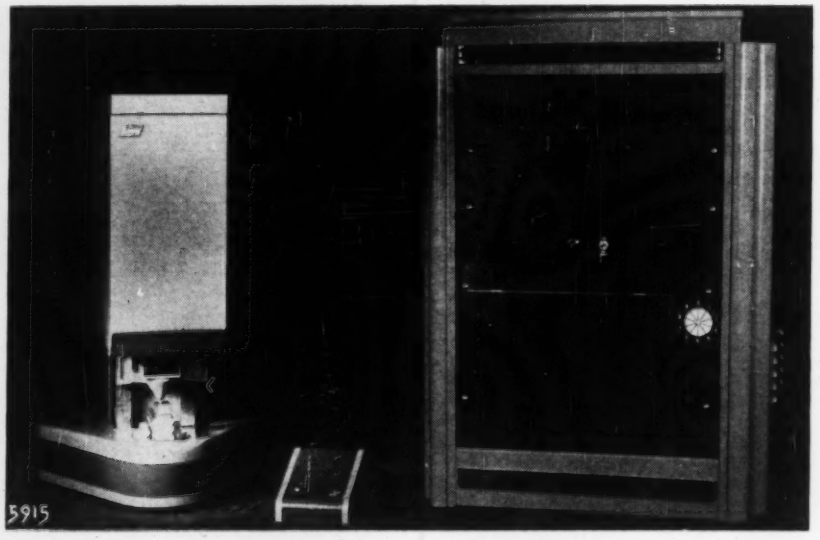
For more information circle **257** on inquiry card.

Illuminated Magnifier

New "Flash-O-Lens" inspection magnifier is available in battery and line-operated models with 5- or 7-



Interference Micrometer



New "Fringecount Micrometer," capable of direct linear measurements to within one microinch, utilizes wavelength of light as a basis of measurement, obviates need for gage blocks or other tangible standards; can be used in a controlled environment to measure to accuracy of 1 microinch; can be used in production work where its high accuracy will serve as a safety factor for less precise measurements; can also be used as a precision comparator with a 2" range of movement from set position. It comprises three units: measuring head, control box, and bidirectional digital counter which displays dimension of part being measured. It is particularly desirable for measuring gage blocks, plug gages, precision instrument parts, etc.—*Link Aviation, Inc., Binghampton, N. Y.*

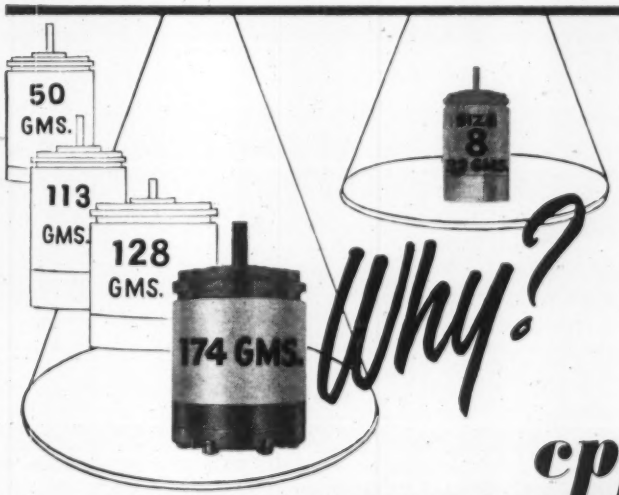
For more information circle **258** on inquiry card.

Function	Type Number	Primary Element	Excitation Voltage 400 cy.	Input Current (ma.)	Input Power (Watts)	Primary Impedance Secondary Open (Phase)	Primary Resistance (line)	Secondary Element	Output Voltage	Secondary Impedance Primary Open (Phase)	Secondary Impedance Primary Shorted	Secondary Resistance (line)	Phase Shift Degrees	Sensitivity mv./deg.	Accuracy Minutes Max.
Transmitter	CGC-8-A-7	Rotor 1 Phase	26	100	.50	54 + j260	37.0	Stator 3 Phase	11.8	12 + j45	15 + j3.5	11.8	8	200	7
Control Transformer	CTC-8-A-1	Stator 3 Phase	11.8	90	.230	28 + j110	24.7	Rotor 1 Phase	23.6	220 + j740	246 + j60	143	8.5	400	7
Control Transformer	CTC-8-A-4	Stator 3 Phase	11.8	37	.091	67 + j270	59.5	Rotor 1 Phase	24	508 + j1680	640 + j190	381	9.2	400	7
Resolver	CSC-8-A-1	Stator 2 Phase	11.8	84	.268	38 + j136	27.0	Rotor 2 Phase	23.2	280 + j600	344 + j75	230	11	400	7
		Rotor 2 Phase	26	39	.430	280 + j600	230.	Stator 2 Phase	10.6	38 + j136	70 + j29	27.0	20	180	7
Repeater	CRC-8-A-1	Rotor 1 Phase	26	.100	.50	54 + j260	37.0	Stator 3 Phase	11.8	12 + j45	15 + j3.5	11.8	8	200	30' *
Differential	CDC-8-A-1	Stator 3 Phase	11.8	85	.21	27 + j120	25.0	Rotor 3 Phase	11.8	38 + j122	47 + j14	36	9	200	7 Rotor 7 Stator

Total Null max. 20mv for each unit

*Torque 2600 mg.-mm. degree from CGC-8-A-7

Also available in 115v 400 cy. primary, 90v secondary Transmitters, C.T.'s, Receivers



WHY USE 1945 SYNCHROS IN 1956 DESIGNS?

Clifton's new Size 8's can take the place of larger units at very significant saving in bulk and *weight*.

These new Size 8's are now in use in some of the latest and *lightest* avionic equipment. In equipment which must be flown, why load on extra weight?

Samples are available from stock, quantities from the production line.

LOOK TO CPPC FOR SYNCHRO PROGRESS

cppc

CLIFTON PRECISION PRODUCTS COMPANY INC.

CLIFTON HEIGHTS **PENNSYLVANIA**

For more information circle **53** on inquiry card.

PALMER

presents

an outstanding improvement in

DIAL THERMOMETERS

external calibration

Full 3½" Dial Face

- No Sector
- No Pinion
- No Linkage
- Constant Accuracy
- Easy Readability

WRITE FOR BULLETIN 350

PALMER

THERMOMETERS, INC.

Norwood Ave., Cincinnati 12, Ohio

Mfrs. of Industrial Laboratory Recording and Dial Thermometers

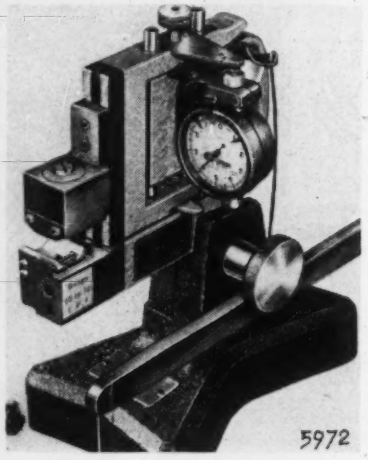
For more information circle **54** on inquiry card.

power lenses, or with 20- or 40-power shop microscopes. Available accessories include textile counting plate, Henry Disc, Battley Disc, etc.—*E. W. Pike & Co., 492 North Ave., Elizabeth 3, N. J.*

For more information circle **259** on inquiry card.

Pitch-diameter Gage

New pitch-diameter gage utilizes "Versa-Dial" gage as fundamental unit. Measurement of pitch diameter

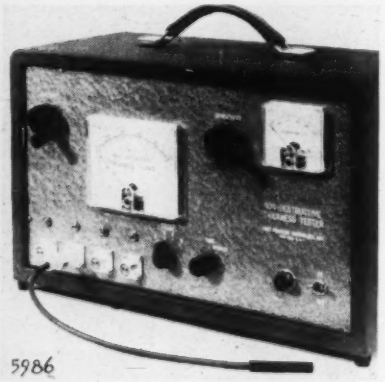


is basically by three-wire method but with wire-holding jaws of such design that operator need not be aware of the wires themselves. Moreover, measuring pressure is the same on workpiece as on master and is independent of human judgment.—*Standard Gage Co., Poughkeepsie, N. Y.*

For more information circle **260** on inquiry card.

Coating-thickness Gage

New non-destructive thickness tester for metal finishing industry permits 100% inspection; can test thick-

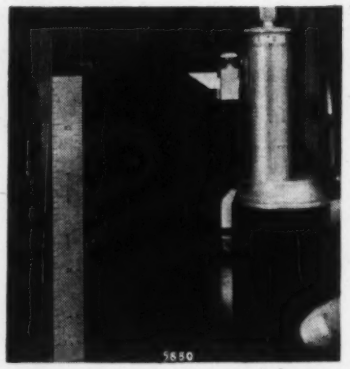


nesses of metals deposited on metals, metals on non-conductors, and non-conductors on metals, in a few seconds.—*Unit Process Assemblies, Inc., 35 E. Wacker Drive, Chicago 1, Ill.*

For more information circle **261** on inquiry card.

Height Gage

New "Micro-Height Gage" is said to give "faster and more accurate readings than any height gage now on the market." Basic gage 2", increased to 3" by reversing scriber. By adding a 3" riser to base, as

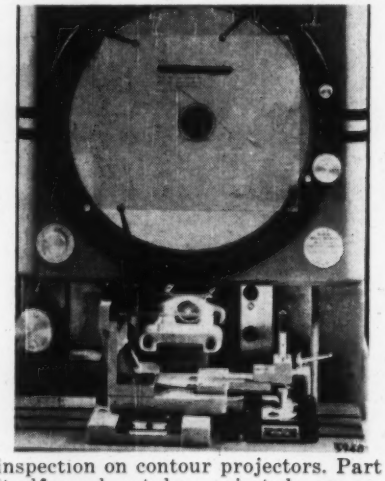


shown, capacity extends to 6". To determine distances between heights or holes, a dial indicator is used in place of steel scriber.—*Greist Mfg. Co., New Haven, Conn.*

For more information circle **262** on inquiry card.

Optical-gaging Tracer Fixtures and Reticles

Four new reticle tracing units permit accurate gaging of many parts heretofore thought too difficult for

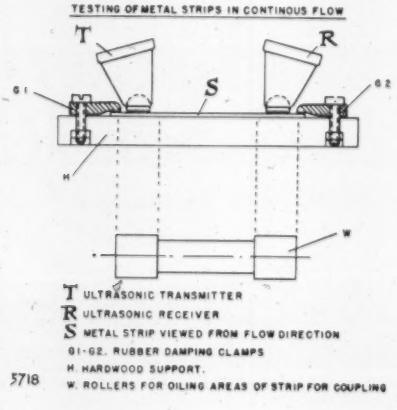


inspection on contour projectors. Part itself need not be projected; an actual-size outline of part with tolerances reproduced on clear glass (called a reticle) is projected on comparator screen. A tracer stylus is linked rigidly to reticle.—*Optical Gaging Products, Inc., 26 Forbes St., Rochester 11, N. Y.*

For more information circle **263** on inquiry card.

Flaw Detector

New "Sonometer" differs from echo principle ultrasonic detectors in that it can spot flaws near a surface and



is not affected by beam angles. Its transmitting head sends a beam directly through entire test object to a separate receiver. Soundheads are available for angular viewing on odd-shaped or inaccessible objects. Any irregularity, such as microscopic cracks, folds in metal, air bubbles, grain variations or gross impurities, effects a response.—*Curtiss-Wright Corp., Specialties Div., Caldwell, N. J.*

For more information circle **264** on inquiry card.

LABORATORY

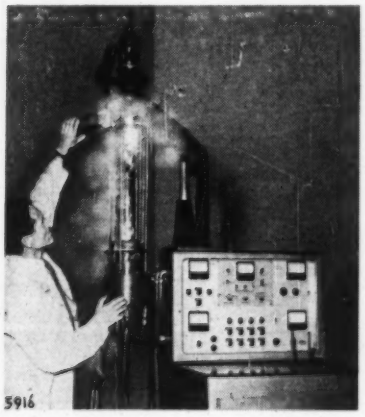
Spectrophotometer

New "Remote Indicating Spectrophotometer," new version of maker's "Rapid Scanning Spectrophotometer," includes all features of original instrument such as spectrum scan cycle of about 6 milliseconds and curve redisplay rate of 60 curves/second. Both instruments record by means of a CRT indicator, but in new instrument CRT indicator is housed separately from optical unit (containing sample chamber) and is connected to it by a cable up to 50' long, whence great freedom for in-process control. ★New "Pulsing Attachment" permits choice of 1 or 6 spectrum scans/second in addition to normal 60 scans/second; advantageous in studying slow reactions, principally in biochemical fields.—*American Optical Co., Southbridge, Mass.*

For more information circle **265** on inquiry card.

Cryostat

New "Magnetic Refrigerator" will maintain lower temperatures than can any previous apparatus: within



a fraction of a degree of 0°K; is based on a cyclic principle of magnetic cooling originated by Drs. John G. Daunt and Clifford V. Heer of Ohio State U.—*Arthur D. Little, Inc., 30 Memorial Drive, Cambridge, Mass.*

For more information circle **266** on inquiry card.

High-temperature Bath

Newly redesigned "Hy-Temp Aging Bath," for tempering, conditioning, preheating and stability tests, as well as routine laboratory work, especially ASTM Methods D 471 and D 735. Thermostat, which controls to 1C° from 35°C to over 250°C, consists of two complete systems, one acting as a

as small as the tube it cools...

ACTUAL SIZE

EAD's subminiature CENTRIFUGAL BLOWER

Here is the most compact centrifugal blower unit made . . . EAD's high-velocity subminiature centrifugal blower is only 2⅞" long, weighs only 6 ounces, yet it can move 13 cfm of air at a velocity of 3,000 feet per minute—and the volume holds up at high static pressures. It is driven by EAD's new one-inch diameter motor. The metal blower housing can be rotated to any position desired for maximum efficiency in cooling radar equipment, amplifier units, transmitter equipment, oscillators, and in other applications where high temperatures in confined areas demand miniaturized blowers with the highest possible performance characteristics. EAD's subminiature blower units meet all applicable MIL specification, and low temperature rise makes them suitable for high altitude and high ambient temperature operation.

CFM	13 @ 0" SP 10 @ 1.0" SP	7 @ 0" SP 5 @ .2" SP
MAX. SP.	2.5	0.6
RPM	20,000	11,000
AMPS	0.1	0.06
WATTS	10.0	6.0
CAPACITOR Mfd/Volts	0.25/220	0.1/220
WEIGHT (OUNCES)	6	6
MODEL NO.	B2GIQ-C	B2HIY-C

Modifications of standard models or completely new designs can be engineered to meet your special cooling needs. Write for complete information.

EASTERN AIR DEVICES, INC.

SOLVING SPECIAL PROBLEMS IS ROUTINE AT EAD

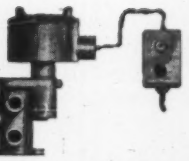
INDUCTION MOTORS · CENTRIFUGAL BLOWERS · TACHOMETER GENERATORS · FANS · ALTERNATORS · GEAR MOTORS

347 CENTRAL AVENUE • DOVER, NEW HAMPSHIRE

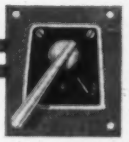
For more information circle **55** on inquiry card.

For Remote Shut-off Applications...

ANNIN CYLINDER VALVES

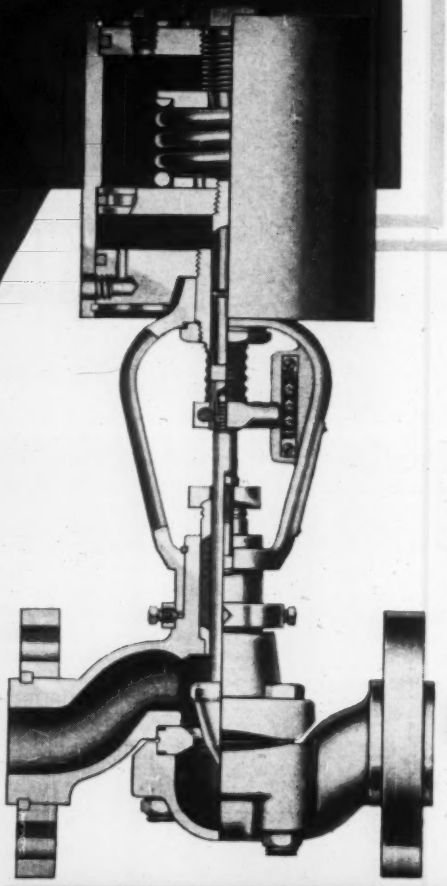


ELECTRO-PNEUMATIC SOLENOID PILOT ACTUATED



3-WAY OR 4-WAY MANUAL AIR ACTUATED

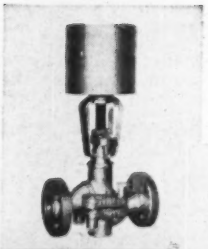
PNEUMATIC CONTROLLER ACTUATED



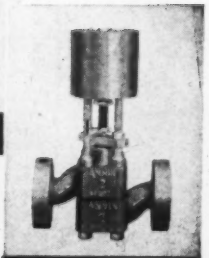
provide the complete answer!

...with these advantages:

- Positive shut-off
- Fast action
- Spring to open
  or
- Spring to close
- Globe, angle & 3-way bodies
- Carbon steel and all cast and forged alloys available
- Metal seats for high temperatures



MODEL 4520



MODEL 6520

and absolute shut-off dependability and safety with **ANNICO TEFSEAL SEATS** proven in dangerous services, such as Liquid Oxygen, Fuming Nitric Acid, Liquid Nitrogen and CO_2, Fuels and other FLUIDS at all pressures and temperatures −300° to + 450° F

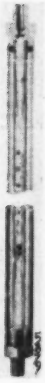
ANNIN *Control* VALVES

THE ANNIN COMPANY
6570 EAST TELEGRAPH ROAD, LOS ANGELES 22, CALIFORNIA

For more information circle **56** on inquiry card.

safety thermostat in event of failure of the other.—*Precision Scientific Co., 3737 W. Cortland St., Chicago 47, Ill.*

For more information circle **267** on inquiry card.



Laboratory Flowmeter

New "Guarded Predictability Flowmeter," designed to withstand hard use, has an outer tube of strong Tenite II plastic to protect glass flowmeter tube. Pipe-end fittings of corrosion-resistant stainless steel and gaskets of Hycar rubber can safely contact fluid. Stainless steel hose ends for connection to rubber tubing are also available.—*The Emil Greiner Co., 20-26 N. Moore St., New York 17, N. Y.*

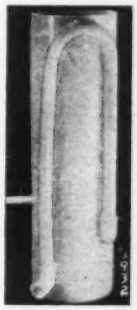
For more information circle **263** on inquiry card.

Fineness Tester

New "Blaine Air Permeability Fineness Tester" determines fineness characteristics of Portland cement, pharmaceutical powders and other granular materials; conforms with current ASTM and Federal specs; features easy calibration, a stainless steel mirror to facilitate manometer readings and prevent parallax, and absence of complicated parts.—*Precision Scientific Co., 3737 W. Cortland St., Chicago 47, Ill.*

For more information circle **267** on inquiry card.

Pipette Rinser



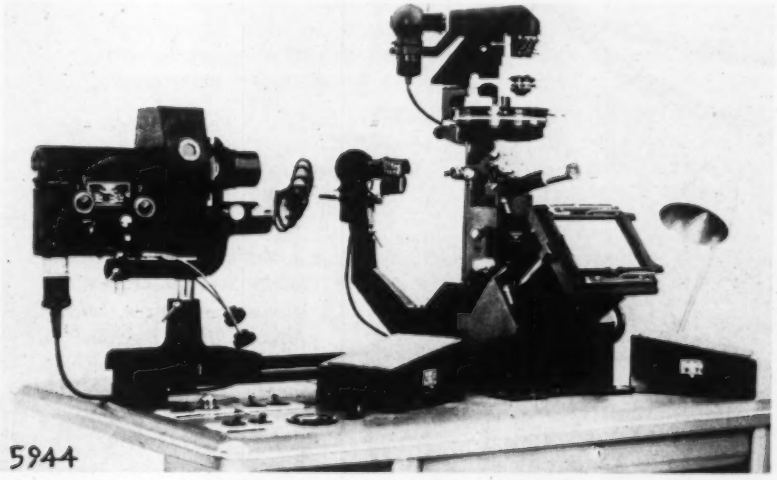
New "Nalgene" automatic pipette washer made of polyethylene will fill and drain in less than two minutes. Inlet is serrated to hold a flexible tube securely; outlet is fitted with a standard ¾" pipe female ell for a permanent drain connection or it may be fitted with a piece of flexible hose.—*The Nalge Co., Inc., 625 S. Goodman St., Rochester 20, N. Y.*

For more information circle **270** on inquiry card.

Paper-strip Electrophoresis Apparatus

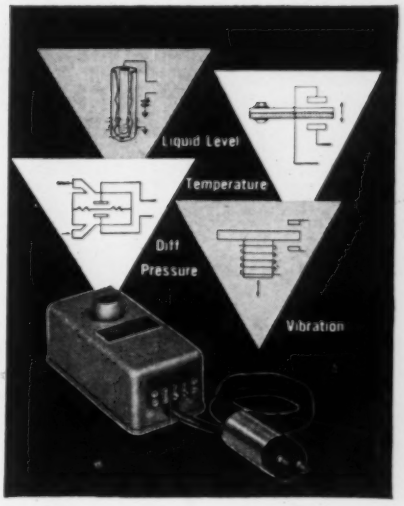
Newly redesigned "Senior Model Ionograph" utilizes electro-migration of ions on wet filter paper in simple

Metallograph



New Reichert (Austrian-made) "MeF Metallograph" is said to feature versality and simplicity of operation combined with a brilliant optical system. Universal opaque illuminator allows all known methods of investigation. Five light sources. Coated, pre-centered "Epilum" and fluorite objectives. Integral photomicrographic camera. Polaroid Land back readily applied; attachment for 35 mm. camera available. Steel control desk with all electrical accessories, lamps, and control panel built in.—*Pfaltz & Bauer, Inc., 350 Fifth Ave., New York 1, N. Y.*

For more information circle **271** on inquiry card.



NOW

measure any variable which you can resolve into capacitance change with this one versatile unit

- Measure micrometric, macrometric displacement . . . linear or angular motion . . . vibration . . . temperature . . . pressure . . . liquid level . . . humidity . . . dielectrica, etc.
- Display, record, control variables with simplicity, versatility, flexibility, low cost, never before possible in capacitive gaging
- Sensitivity as high as 5 volts per μμFAC
- Phase sensitive d-c output signal as high as ±60 volts . . . yet stable enough to measure 0.01 volts

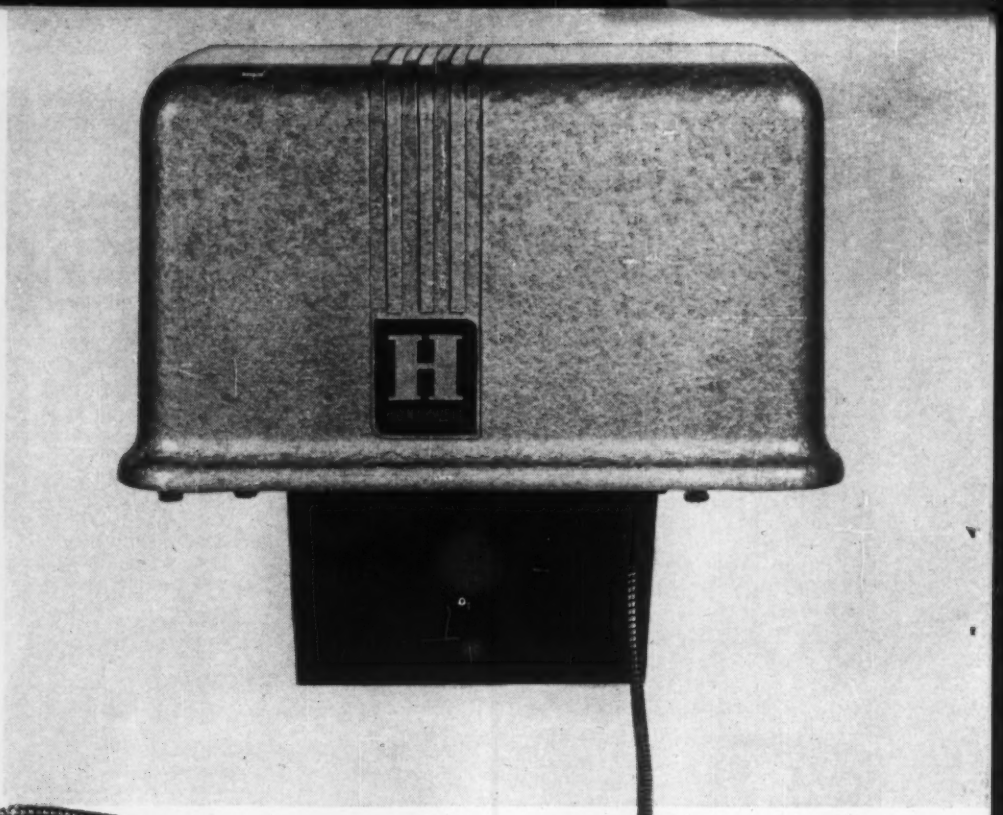
Here is a capacitance-to-voltage analog transducer *so versatile* that its usefulness is as limitless as your own imagination. Based on the famous **"T-42" Ionization Transducer,** Decker's new "Delta Unit" is amazingly simple and compact . . . with no frequency stabilized oscillator, bridge, phase sensitive rectifier, or discriminator. You provide a simple power supply and indicator . . . connect the desired capacitance configuration to the Delta Unit . . . and an analagous output signal is immediately available.

Detailed information on the Decker Delta Unit—priced at $115.00 complete with probe and cable—is in Instrument Data Sheet 901-1, available upon request to Technical Literature Section.

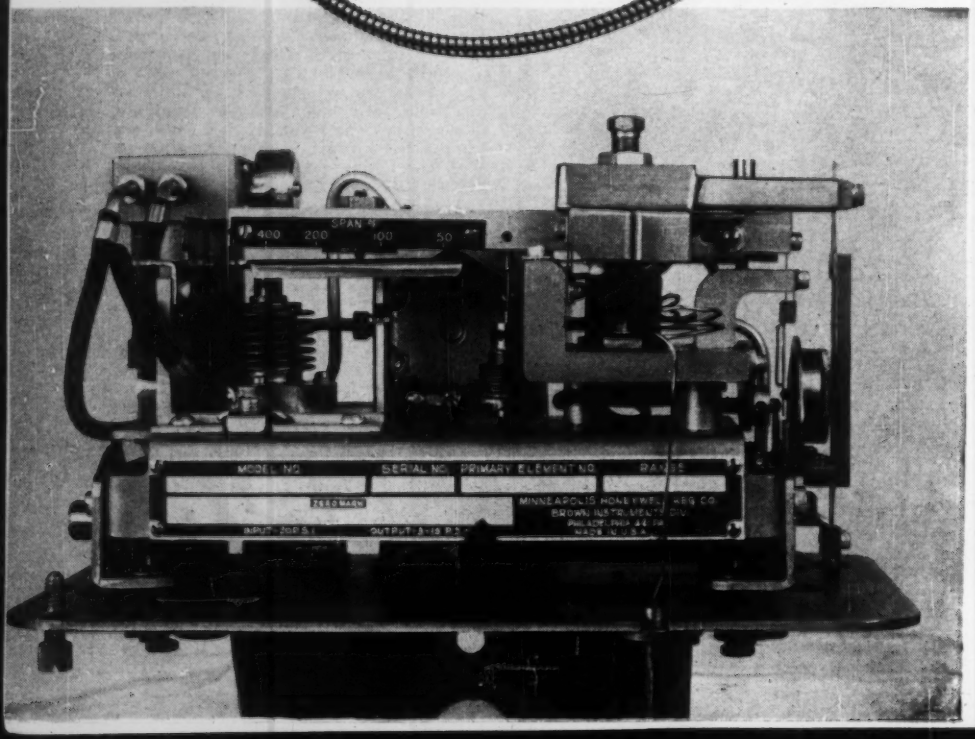
DECKER AVIATION CORPORATION
1361 Frankford Avenue, Phila. 25, Pa.

decker

For more information circle **57** on inquiry card.



The Tel-O-Set transmitter is housed in a rugged, weather-resistant case, only 6½" by 11¾" by 6¾". It is readily mounted in the field . . . on pipe, wall, or horizontal well.



Interior view of the transmitter with cover removed shows the simple, sturdy force-balance mechanism. Span and zero adjustments are easily accessible . . . require no changes of parts.

For more information circle **58** on inquiry card.

Compare it!

The same *Tel-O-Set* Transmitter can be used for temperature, absolute pressure or gage pressure—in all ranges

Changeover is simple... takes little time and labor. And, there's no need to stock an assortment of thermal systems or spring assemblies.

Tops in performance, too...

In accuracy • In speed of response • In ambient temperature and pressure compensation • In resistance to vibration • In durability • In ease of adjustment and calibration • In operating economy

Span can be adjusted to any values between 20 psi or 50 F minimum, and 150 psi or 400 F maximum. Without changing parts, the span can be shifted to cover any part of the overall transmitter range . . . from −375 to + 1000 F, or from 40 to 550 psi.

This multi-purpose instrument will simplify the training of your operating and maintenance men . . . reduce spare parts inventory. And a single instrument does double duty as a standby replacement for either temperature or pressure applications. Its sturdy, corrosion resistant mechanism assures long service life.

Your local Honeywell sales engineer will be glad to discuss how the *Tel-O-Set* transmitter . . . and related *Tel-O-Set* miniature indicators, recorders and controllers . . . can work for you. Call him today . . . he's as near as your phone.

MINNEAPOLIS-HONEYWELL REGULATOR CO., *Industrial Division*, Wayne and Windrim Avenues, Philadelphia 44, Pa.—in Canada, Toronto 17, Ontario.

● **REFERENCE DATA: Write for Bulletin 7280, "*Tel-O-Set* Transmitters."**

MINNEAPOLIS **Honeywell**

BROWN INSTRUMENTS

First in Controls

For more information circle **58** on inquiry card.

Genisco Rate-of-Turn Tables facilitate fast, precise calibration and evaluation of rate gyros

Ball-disc integrator drive provides infinitely variable rates from 0.01° to 1200°/sec.

EXTREMELY ACCURATE... constancy of angular velocity of the turntable is within 0.1%, including wow and drift errors, at any rate.

SMOOTH, CONSTANT ROTATION... unique synchronous motor, designed specially for this application, has large diameter rotor; high polar inertia.

EASY TO OPERATE... single handwheel controls turntable speed. Inexperienced personnel can operate machine after few minutes instruction.

IDEAL FOR LARGE VOLUME TEST PROGRAMS... ruggedness, simple operation, repeatability, and versatile mounting facilities make it the ideal machine for production-line testing.

PRECISE REPEAT POSITIONING... within 0.2% in same rotational direction; 0.5% in opposite direction, under 500° per second.

LOW ELECTRICAL NOISE LEVEL... better than −55 dbm per slip ring circuit (zero dbm = 1 mw in 600 Ω).

UNUSUALLY RUGGED... built to take years of continuous use; requires only minimum amount of maintenance.

TABLE CAPACITY... 100 pounds.

ACCESSORIES INCREASE ITS USEFULNESS!

SUB-RANGE ADAPTER... extends low range of Genisco Rate-of-Turn Table to 0.0001° per second.

PRECISION STROBE UNIT... for use in areas where accuracy of line frequency is questionable, or for calibration of gyros with accuracies better than line frequency.

MOUNTING STANDS... available in portable and fixed models.

Send today for complete specifications. Please direct your inquiry to Contracts Manager, Genisco, Incorporated, 2233 Federal Avenue, Los Angeles 64, California.

RELIABILITY FIRST

Genisco INCORPORATED

For more information circle **59** on inquiry card.

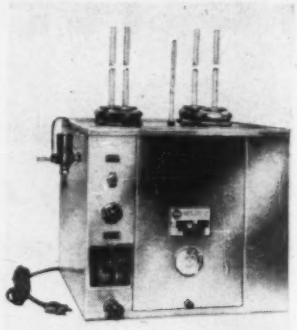
NEW INSTRUMENTS

fractionations, mobility determinations and reaction site studies; provides widest range available in this type of instrument; from 150 to 2000 volts. New specially-designed dc filter system regulates voltage within 1.7%. —*Precision Scientific Co.*, 3737 *W. Cortland St., Chicago* 47, *Ill.*

For more information circle **272** on inquiry card.

Air-well Bath

New air-well bath for detection of free and corrosive sulphur compounds (Method 5313) has a control main-



taining constant temperature of 122°F or 212 ± 0.9°F; 4 air wells, thermometer, 4 glass condensers, 4 four-ounce bottles, test tubes, polishing vise, test and operating manuals.—*Modern Laboratory Equipment Co., Inc.*, 1809 *First Ave., New York* 28, *N. Y.*

For more information circle **273** on inquiry card.

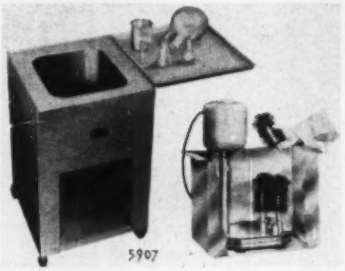
Milligram Weights

New weights, in milligram denominations, are made of a special aluminum alloy in thicknesses from 0.021" down to 0.005" with thickness tolerances of 0.00025" down to 0.0001".—*American Silver Co.*, 36-07 *Prince St., Flushing* 54, *N. Y.*

For more information circle **274** on inquiry card.

Lab Glassware Washer

New "Power Scrub" minimizing labor costs and eliminating glassware breakage, has four motor-driven in-

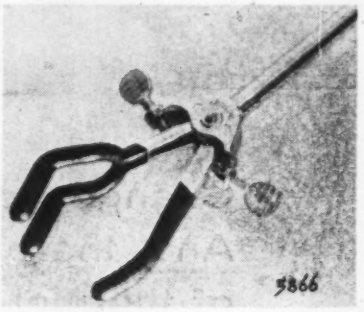


terchangeable Nylon brushes with rigid spindles. Operator cannot get injured. Selection of 9 Nylon brushes covers all types of glassware.—*Labline, Inc.*, 3070 *W. Grand Ave., Chicago* 22, *Ill.*

For more information circle **275** on inquiry card.

Laboratory Clamps

Newest in maker's line of "Castalloy" clamps and holders: jaws hot-dipped in a tough vinyl plastisol



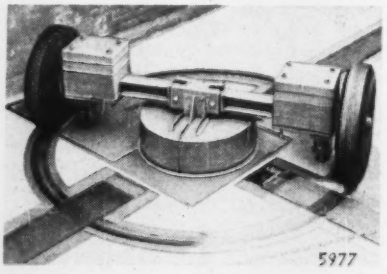
which replaces rubber "sleeves" formerly used and becomes an integral part of clamp with better heat resistance and aging qualities. "Castalloy" clamps will still be available with asbestos jaws for special purposes.) —*Fisher Scientific*, 717 *Forbes St., Pittsburgh* 19, *Penna.*

For more information circle **276** on inquiry card.

MECHANICAL TESTING

Treadle Tester

New treadle tester simulates action of front end of a passenger vehicle weighing 3,500 lbs passing over T&C

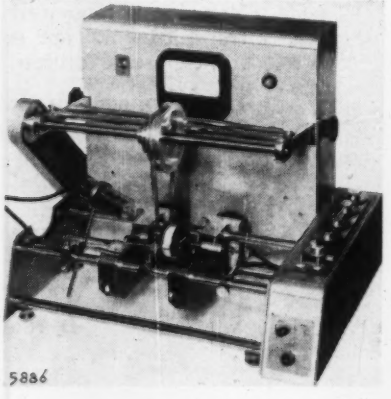


four-contact treadle. Mechanism revolves at a speed approximately 12 mph; is adjustable to 30 mph for evaluating wear of treadle at higher speeds.—*Taller & Cooper, Inc.*, 75 *Front St., Brooklyn, N. Y.*

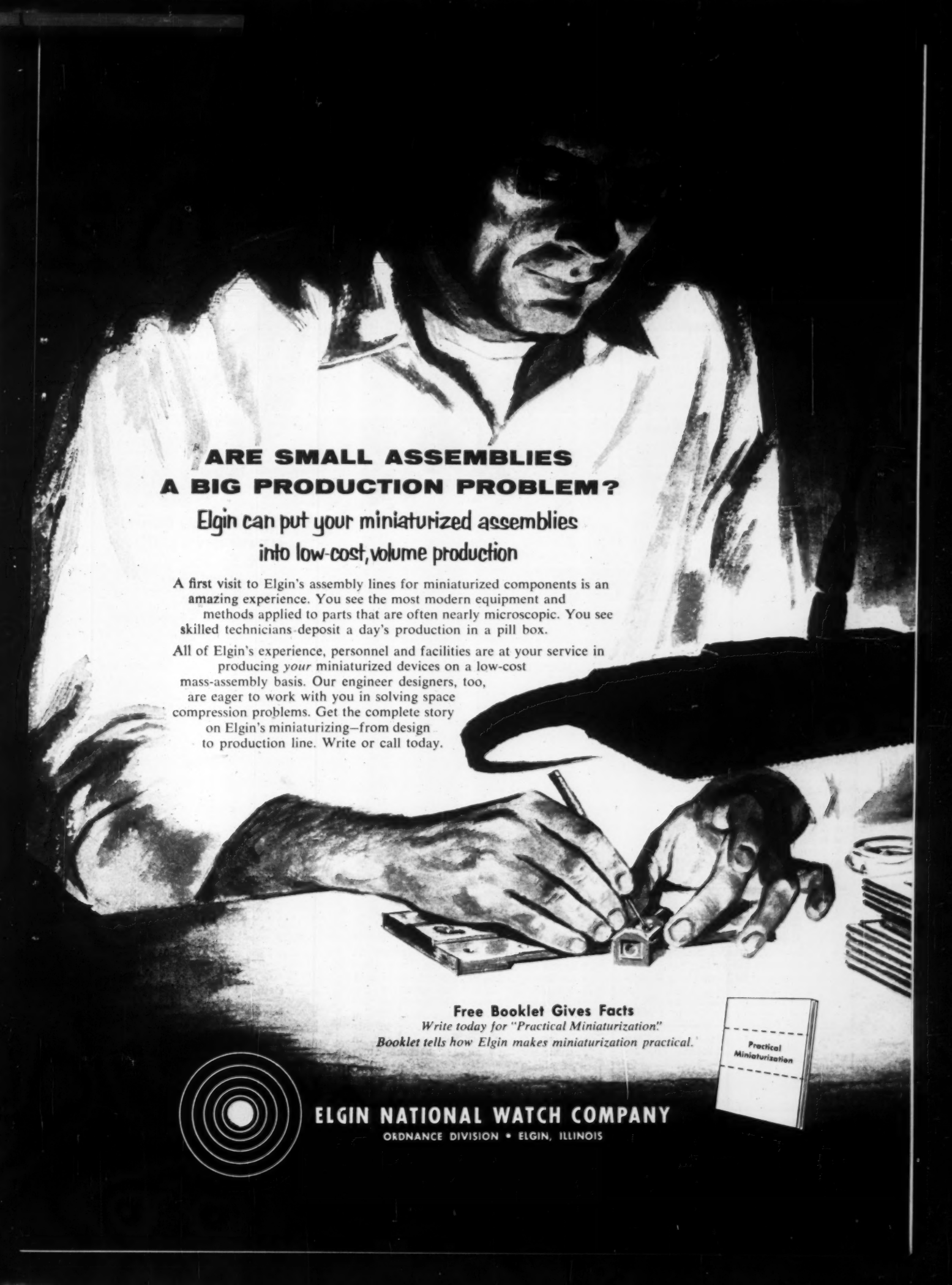
For more information circle **277** on inquiry card.

Dynamic Balancing Machine

New "Type 1250" balancing machine quickly and accurately locates out-of-balance in two planes of correction and indicates needed amount



Circle **60** on inquiry card. ⟶


ARE SMALL ASSEMBLIES
A BIG PRODUCTION PROBLEM?
Elgin can put your miniaturized assemblies into low-cost, volume production
A first visit to Elgin's assembly lines for miniaturized components is an amazing experience. You see the most modern equipment and methods applied to parts that are often nearly microscopic. You see skilled technicians deposit a day's production in a pill box.
All of Elgin's experience, personnel and facilities are at your service in producing *your* miniaturized devices on a low-cost mass-assembly basis. Our engineer designers, too, are eager to work with you in solving space compression problems. Get the complete story on Elgin's miniaturizing—from design to production line. Write or call today.
Free Booklet Gives Facts
Write today for "Practical Miniaturization."
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Practical Miniaturization
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where stability is a must . . .

TIC®

PRECISION TRIMMER POTENTIOMETERS

small..compact..precise

Engineered to the high standards of TIC Quality . . . a familiar standard of comparison. Environmental tested for MIL-E-5272A. TIC's Trimmer Potentiometers may be used as adjustable resistors or voltage dividers.

for

- Adjusting scale factors of functions basically derived by other potentiometers
- Pinpointing circuit values of voltage, current, or resistance
- Balancing adjustments
- Critical magnetic or electric bias
- Padding or fixed reference circuits
- Establishing critical threshold voltages
- Fixed gain adjustments
- Compensation for variable parameters

RV⅞ MINIATURE TRIMMER

- ⅞" diameter, threaded bushing mounting, aluminum cup construction
- Dissipation: 2.0 watts at 25°C
- Resistance values: 50 ohms to 15K
- Temperature range: −55°C to +80°C

RV½ SUBMINIATURE TRIMMER

- ½" diameter, threaded bushing mounting, stainless steel case
- Dissipation: 1.5 watts at 25°C
- Resistance values: 50 ohms to 15K
- Temperature Range: −55°C to +80°C

RFT SUBMINIATURE METLFILM TRIMMER

- 13/32" x .400 x 1 21/64", rectangular case, 2 screw eyelet mount, 25 turn lead screw adjustment
- Size permits stacking 7 per square inch
- Infinite resolution
- Dissipation: 0.5 watts at 40°C
- Resistance values: 50 ohms to 25K
- Temperature range: −55°C to +125°C

RVH1 HIGH TEMPERATURE TRIMMER

- 1" diameter, threaded bushing mounting, aluminum cup construction
- Dissipation: 2 Watts at 25°C, 0.5w at +130°C
- Resistance values: 100 ohms to 5K
- Temperature range: −55°C to +145°C

For further information regarding your trimmer requirements, TIC invites your inquiries.

TECHNOLOGY INSTRUMENT CORP.

849 Main Street, Acton, Mass.

P.O. Box 3941, North Hollywood, Calif.

For more information circle **61** on inquiry card.

NEW INSTRUMENTS

of correction; can be used by an unskilled operator after brief instruction. Balancing of components usually takes less than 30 seconds.—*Hickok Electrical Instrument Co., 10519 Dupont Ave., Cleveland 8, Ohio.*

For more information circle **278** on inquiry card.

Machinery "Stethoscope"

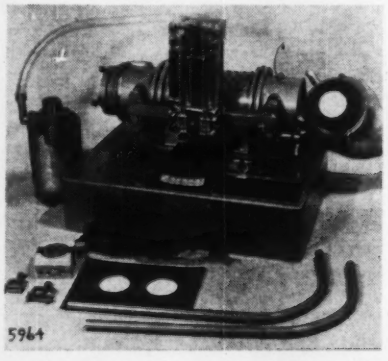
New "Auditec" (English-made) for detecting faults and bearing failures, leaks in pipe-lines, surface flaws, etc.

weighs 2½ lbs, comprises a contact-microphone encased in a probe handle, a 3-stage amplifier and plug-in headphones. Visual measurement can be obtained by adding an output meter. —*John Ould, (U.S.A.) Ltd., 519 South Fifth Avenue, Mount Vernon, N. Y.*

For more information circle **279** on inquiry card.

Air Filter Efficiency Tester

New "Dill Dust-spot Tester" measures efficiency of all types of air filters in ventilating systems. Method



has been called "Bureau of Standards Blackness Test." For the first time a portable instrument is commercially available. It draws samples of air simultaneously through two filter papers, from upstream and downstream of filter to be tested. Flows of air through filter papers are kept in such ratio that papers become dirty at equal rates (by zeroing a galvanometer connected to two photocells). Ratio of sampling rates is then an index to efficiency of filter under test. A continuous record of efficiency of a filter over a period of time is possible.—*Research Appliance Co., 143 Cemetery Lane, Pittsburgh 9, Pa.*

For more information circle **280** on inquiry card.

SERVO MOTORS

from FORD INSTRUMENT for EXTREMELY LOW INERTIA AND HIGH FREQUENCY RESPONSE

- STANDARD SERVO MOTORS in nominal ratings of 10w, 5w, 2½w, 1½w and ½w
- SPECIALS to customer requirements.

Ford Instrument's high precision servos are available in high and low voltage models, in 60cy and 400cy designs, for a multitude of applications. With Ford's smooth iron, low-inertia rotors, they offer these advantages:

- Linear torque-voltage characteristics
- Linear torque-speed characteristics
- Withstand continuous stalling
- High torque efficiency

FREE—Fully illustrated data bulletin gives specifications and performance information. Address Dept. IA.

48

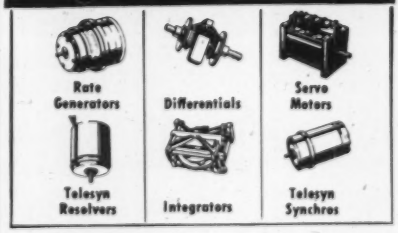
FORD INSTRUMENT COMPANY

Division of Sperry Rand Corporation

31-10 Thomson Ave.

Long Island City 1, N. Y.

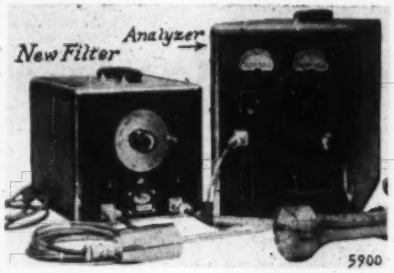
Ford Instrument's standard components



For more information circle **76** on inquiry card.

Variable-frequency Filter and Vibration Analyzer

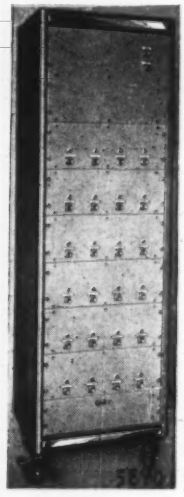
New "Model 1064" continuously variable filter (at left in photo) and Vibration Analyzer (right) provide



direct reading of displacement of one or all vibration frequencies in mechanism under study by tuning filter to desired frequency or scanning vibration frequency spectrum. Tuning range 500 to 50,000 cpm (companion "Model 1065" to 500,000 cpm).—*Internatl. Research & Development Corp., P.O. Box* 1707, *Columbus* 16, *Ohio.*

For more information circle **281** on inquiry card.

Data-reduction Filter

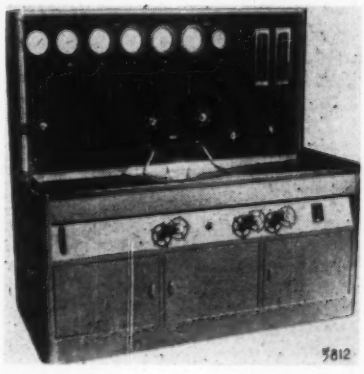


New data reduction filter set is for analyzing vibration frequencies in aircraft and missiles. In use, a tape recorder containing complex wave form is fed into unit, which separates component frequencies into 24 components. Unit comprises 24 cathode-follower amplifiers which feed 23 band-pass filters ranging progressively from 30 to 2000 cps and one 20-cps low-pass filter. Outputs of all filters appear on jacks on front panel. —*Hycor Co., Inc.,* 11423 *Vanowen St., North Hollywood, Calif.*

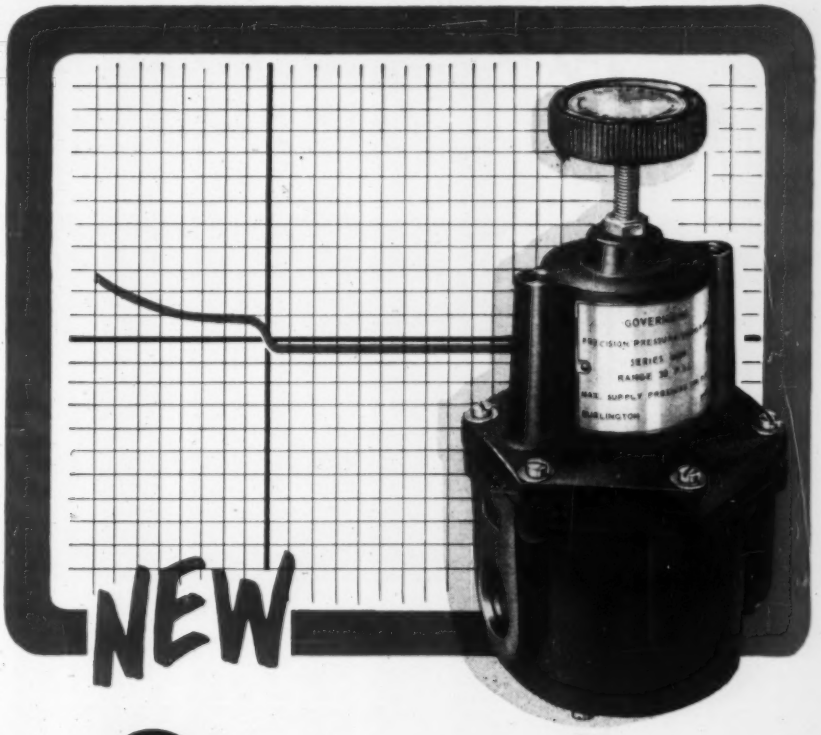
For more information circle **282** on inquiry card.

Hydraulic Test Stand

New "Model 2632" tests performance of hydraulic valves, regulators, actuators, etc.; provides infinitely variable pressure from 500 to 5000 psi and variable flows to 10 or 20 gpm. Cross gage manifolding temperature



ONLY ONE REGULATOR PROVIDES PNEUMATIC CONTROL LIKE THIS!



Governaire

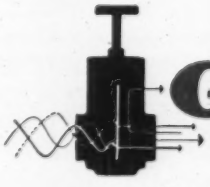
ZERO | ZONE

PRECISION PRESSURE REGULATORS

"Governaire" is the name of an entirely new design and achievement in precision controls for pneumatic loading. They differ from ordinary, existing instruments in their superior accuracy, greater reliability, improved immunity to variations in supply pressure and ability to fill or exhaust a remote volume far more rapidly. Typical flow curve shown above (Series 4000) graphically illustrates Governaire's minimum pressure offset effect as *Zero-Zone* is passed.

Typical specifications of the Series 4000 Regulator include five ranges (10, 30, 60, 150 and 250 psi); high capacity ⅝" diameter supply and exhaust seats (no other regulator of equal pipe size has even a *supply* capacity equal to the Series 4000 *exhaust* capacity); three sizes (⅜", ½" and ¾" NPT with two ¼" gauge taps). The Series is especially suited to such machine applications as welding head pressure control, punch press brake and clutch control, cable and sheet tensioning devices, etc.

Series 4000 is one of eight Governaire precision control devices now in production and available for delivery. Descriptive information and performance data on any will be sent on request. Write, outlining your application.



Governaire

DIVISION OF BELLOFRAM CORPORATION
BURLINGTON, MASSACHUSETTS

For more information circle **62** on inquiry card.

SAR PULSESCOPE

by Waterman

MODEL S-4-C

DIRECT-READING DELAYED SWEEP ACCURATE TO 0.1%

Size:
9⅛" x 11¼" x 17¼"
31.5 Pounds

ANOTHER EXAMPLE OF Waterman PIONEERING...

The SAR PULSESCOPE, model S-4-C, is JANized (Gov't Model No. OS-4), the culmination of compactness, portability, and precision in a pulse measuring instrument for radar, TV and all electronic work. An optional delay of 0.55 microseconds assures entire observation of pulses. A pulse rise time of 0.035 microseconds is provided thru the video amplifier whose sensitivity is 0.5V p to p/inch. The response extends beyond 11 mc. A and S sweeps cover a continuous range from 1.2 to 12,000 microseconds. A directly calibrated dial permits R sweep delay readings of 3 to 10,000 microseconds in three ranges. In addition, R sweeps are continuously variable from 2.4 to 24 microseconds; further expanding the oscilloscope's usefulness. Built-in crystal markers of 10 or 50 microseconds make its time measuring capabilities complete. The SAR PULSESCOPE can be supplied directly calibrated in yards for radar type measurements. Operation from 50 to 400 cps at 115 volts widens the field application of the unit. Countless other outstanding features of the SAR PULSESCOPE round out its distinguished performance.

WATERMAN PRODUCTS CO., INC.

PHILADELPHIA 25, PA.
CABLE ADDRESS: POKETSCOPE

WATERMAN PRODUCTS INCLUDE

S-4-C SAR PULSESCOPE®
S-5-A LAB PULSESCOPE
S-6-A BROADBAND PULSESCOPE
S-11-A INDUSTRIAL POCKETSCOPE®
S-12-B JANized RAKSCOPE®
S-14-A HIGH GAIN POCKETSCOPE
S-14-B WIDE BAND POCKETSCOPE
S-15-A TWIN TUBE POCKETSCOPE
RAYONIC® Cathode Ray Tubes and Other Associated Equipment

For more information circle **63** on inquiry card.

control and indication, oil temperature control and indication, oil temperature control and indication are also provided. Stand is ready for operation after connection to a 220/440-v 60-cps 3-phase line and to water supply and drain.—*Auto-Control Labs.*, 5665 *Selmaraine Drive, Culver City, Calif.*

For more information circle **283** on inquiry card.

Pneumatic Oscillator

New "Servo-Gauge" pneumatic oscillator generates a square wave of pressure at constant, but adjustable, frequency and amplitude; is entirely pneumatic and contains no moving parts. In standard unit, frequency of output wave is adjustable from 3 minutes per cycle to 50 cycles per minute by a simple dial adjustment. (Units with frequencies up to 300 cycles per minute can be provided.) Amplitude, in standard unit, is adjustable over a range of 0 to 30 psi. Among major applications: controlling stroking rate and stroke length of pneumatically-powered proportioning pumps. It uses no electric energy: desirable where flammable materials exist. It operates as well on gas as on air.—*Servo-Gauge Mfg. Co.*, 1450 *Timber Trails Drive, Elmhurst, Ill.*

For more information circle **284** on inquiry card.

Kinematic Viscosity Bath

Newly redesigned "Model S Kinematic Viscosity Bath" provides easier and more accurate viscosity determinations; conforms with all requirements of ASTM, AAF and Federal specs; accommodates six suspended level viscosity tubes of any standard length. Temperature uniformity 0.01F°; virtually stepless power input control.—*Precision Scientific Co.*, 3737 *W. Cortland St., Chicago* 47, *Ill.*

For more information circle **285** on inquiry card.

Bar and Tube Inspector

New automatic testing equipment nondestructively inspects non-magnetic stainless steel bars and tubing,

5919

both seamless and welded; signals audibly and visually external mechanical defects in bars, such as cracks, seams and slivers. In seamless and welded tubing, it indicates mechanical defects both on inside and outside diameters, as well as imperfect welds. Testing speed is about 200 fpm.—*Magnetic Analysis Corp.*, 42-44 *12th St., Long Island City, N. Y.*

For more information circle **286** on inquiry card.

Endurance Rated
ELECTRIC COUNTERS and ACTUATORS
to Fit every need

200,000,000 COUNT LIFE

PIC
SUPER-WIZARD

1000 CPM.
5 watts input.
Balanced Armatures.
4 and 6-digit models in basemount, panelmount and dustproof enclosed types for 60, 40-50, 25 cycles and DC; all voltages to 230.
Purchase cost only 18c per million counts.

50,000,000 COUNT LIFE

PIC
600

1000 counts per minute
7 watts power consumption
Balanced armature
Quiet operation. No AC hum.
Tamper proof housing.
Lubrication not required.
Available in basemount and panelmount models—also to count dozens, for 60, 40-50, 25 cycles and DC; all voltages to 150.

6,000,000 COUNT LIFE

PIC MERCURY
4-digit Reset

600 Counts per minute.
3 watts power input.
4-digit Basemount and Panelmount models also to count dozens — all voltages to 115, AC or DC.

3,000,000 COUNT LIFE

PIC MERCURY
5-digit non-reset

600 Counts per minute.
3 watts power input.
Tamper proof construction.

See your PIC Representative or write

PIC
PRODUCTION INSTRUMENT CO

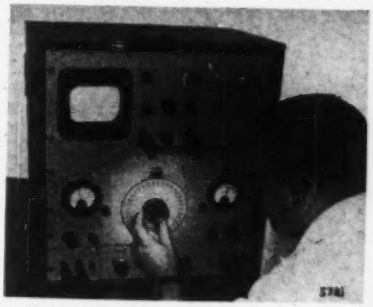
702 W. Jackson Chicago 6, Illinois

For more information circle **64** on inquiry card.

ELECTRICAL TESTING

System Analyzer

New "Servoscope" models can be obtained with a matched cathode-ray indicator. Combined instruments are

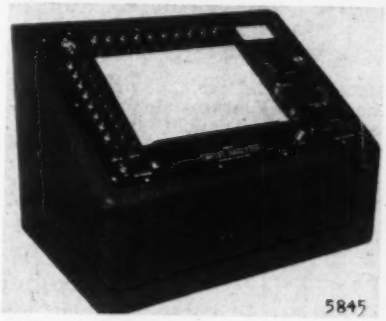


available in one cabinet or ready for rack mounting. "Servoscope" is a multiple signal generator for measuring gain and phase shifts of ac carrier and dc servo systems. Four models offer frequency ranges from 0.001 to 60 cps.—*Servo Corp. of America, 20-20 Jericho Turnpike, New Hyde Park, L.I., N. Y.*

For more information circle **287** on inquiry card.

Circuit Analyzer

New "Model 80 Automatic Electrical Circuit Analyzer" can automatically test 80 circuits in one operation

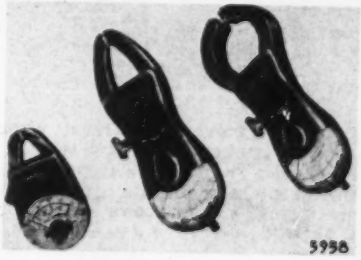


taking 8 seconds; is the equal of 200-circuit "Model 200" in every detail except capacity. Among features is complete flexibility: tester itself never has to be modified; can test for all types of errors, functionally test relays, solenoids and other devices, and automatically test every type of multiple interconnected cable system for continuity, shorts, or insulation resistance.—*DIT-MCO, Inc., 505 W. 9th St., Kansas City; Mo.*

For more information circle **288** on inquiry card.

Snap-around Volt-ammeters

Three new high-voltage "Amprobe Junior" models round out complete line for all types of electrical serv-



The Model TC-2 Temperature Test Chamber is a portable, self-contained, easy-to-operate unit ideal for laboratory and production line use.
Write for literature.

Temperature Range: −65°F to +350°F.
Holding Accuracy: ±2°F
Coolant: Dry ice, 15 lbs. capacity.
Dry Ice Loading Port.
Heater: Electric Strip Heater.
Control: Thermostat, balancing heat against dry ice evaporation. Permanent Thermometer.
Test Load Access: Removable tray, with 15 through ports.
Test Load Capacity: 600 cubic inches.
Power Requirements: 115 volts, 5 amperes, 50-60 cycles, single phase.

STATHAM DEVELOPMENT CORPORATION
12411 W. Olympic Blvd., Los Angeles 64, Calif.

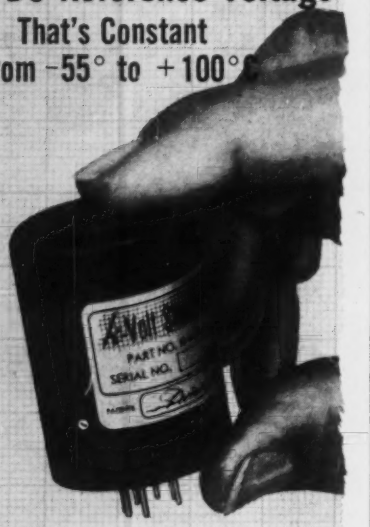
PRICE $550.00
F.O.B. LOS ANGELES

For more information circle **65** on inquiry card.

NOW . . .

a DC Reference Voltage

That's Constant from −55° to +100°C



K-Volt Standard*

Tubeless Constant Voltage Source For Measurement & Control Circuits

Designed to replace the chemical cell and VR tube in airborne, laboratory and other critical instrumentation, the K-Volt Standard provides constant voltage through extremes of operating conditions . . . including ambient temperatures as low as −55° and up to 100°C. Operating from AC or DC supply, it employs no tubes or moving parts, is unaffected by position, vibration or mechanical shock. Negligible temperature coefficient, dependable regulation characteristics and rugged design make it applicable as an absolute reference, a constant output working supply, or a precision voltage regulator wherever specifications demand highest stability. Other important features are:

- **Small size: 1½" by 1¼" dia.**
- **Power drain less than 1.8 watts**
- **Life: more than 10,000 hrs.**
- **Vibration: conforms to MIL-E-5272A**
- **Miniature 7-pin base**
- **Weight: less than 3 oz.**
- **Hermetically sealed**
- **Random drift less than 0.1% over 1000 hrs.**

Models to Meet Wide Range of Application Requirements: The K-Volt Standard is available for operation from 26.5 volts DC, or 117 volts AC, 60 or 400 cycles; DC output 6 volts or 1 volt, at 1 ma or 10 ma.

For complete specifications and performance data send for bulletin No. E128

*TRADE MARK

Avien

Precision Instruments and Control Systems
58-15 Northern Blvd., Woodside 77, N. Y.

For more information circle **87** on inquiry card.

NEW INSTRUMENTS

icing and installation.—*Pyramid Instrument Corp., 630 Merrick Rd., Lynbrook, N. Y.*

For more information circle **289** on inquiry card.

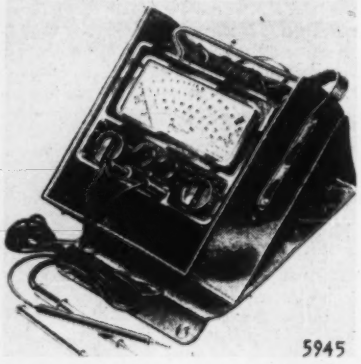
Five-inch CRO

New "#460" 5" cathode-ray oscilloscope, offered in kit and wired form, has 5-Mc bandwidth (flat to 4.5 Mc and usable above 5 Mc); is said to "fulfill the most exacting requirements for laboratory, production line, and monochrome and color TV servicing."—*Eico, 84 Withers St., Brooklyn 11, N. Y.*

For more information circle **290** on inquiry card.

Vacuum-tube Voltmeter

New "777" VTVM is a self-contained ready-to-use test instrument with accessories including high-frequency co-axial cable, dc probe and ac line cord. Features include illuminated scales; double shielded 200-microamp movement; 42 unduplicated ranges; two zero-center scales for FM discriminator.—*The Phaostron Co., 151 Pasadena Ave., South Pasadena, Calif.*



For more information circle **291** on inquiry card.

Laboratory Oscillator

New "Type 347 Extended-range Oscillator" is said to combine advantages of extended frequency range, low price, extremely small weight and size, and high output. Range 18 cps to 1.1 Mc; weight 6 lb; open circuit output voltage 10v; distortion less than 0.2% over most of useful range; can operate on power supplies of 50 to 400 cps (therefore can be used in airborne applications).—*Technical Products Div., Allen B. Du Mont Labs, Inc., 760 Bloomfield Ave., Clifton, N. J.*

For more information circle **292** on inquiry card.

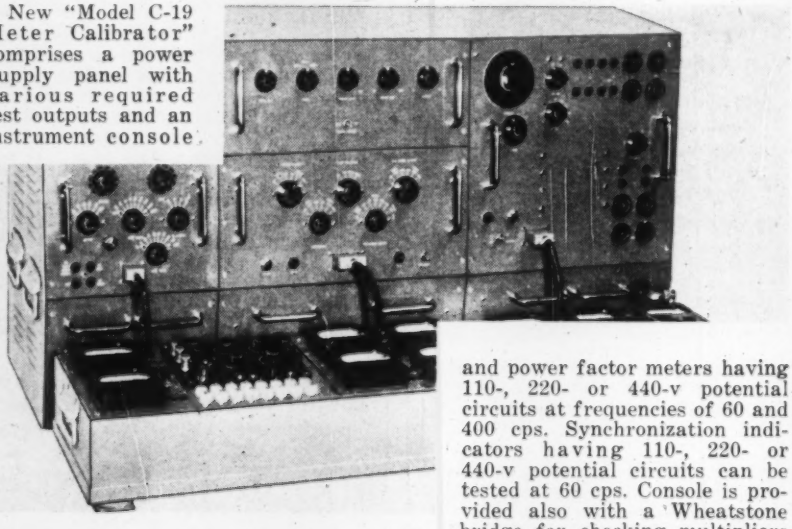
Sine-wave Generator

New "Type 348" sine-wave generator, for a wide variety of electronic lab and field work, features an extended low-frequency range, high output power, low distortion, and a calibrated output control including a four-step decade attenuator. Frequency accuracy 2%, with vernier tuning and a scale length of 14" on each range. Five-decade tuning ranges and an additional band-spread high frequency range are provided.—*Technical Products Div., Allen B. Du Mont Labs., Inc., 750 Bloomfield Ave., Clifton, N. J.*

For more information circle **293** on inquiry card.

Instrument Calibrator

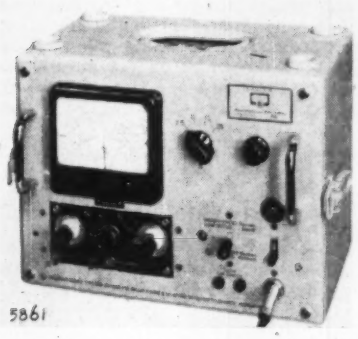
New "Model C-19 Meter Calibrator" comprises a power supply panel with various required test outputs and an instrument console including twelve comparison standards. Instruments can be tested at frequencies from 60 to 800 cps. Single- and three-phase outputs are available for testing wattmeters, varmeters, and power factor meters having 110-, 220- or 440-v potential circuits at frequencies of 60 and 400 cps. Synchronization indicators having 110-, 220- or 440-v potential circuits can be tested at 60 cps. Console is provided also with a Wheatstone bridge for checking multipliers and with resistors from 10 ohms to 100 megohms for calibrating ohmmeters.—*National Instrument Laboratories, Inc., 6108 Rhodes Island Ave., Riverdale, Md.*



For more information circle **294** on inquiry card.

Resistance, Capacitance and Inductance Tester

New "Type KZS Tolerance Indicator" for rapid production testing of resistors, capacitors and inductors by



comparison with an external standard, gives direct readings in per cent on a 4" indicator; four tolerance ranges with sensitivities as high as 2.5% full scale. Ranges include 10 ohm to 1 megohm, 10 uuf to 1 uf, and 100 uh to 2 mh; accuracy ±5% of full scale. Use of a deflection method, as opposed to a null-balance method, permits fast reading.—*Instrument Div., Federal Telephone & Radio Co., 100 Kingsland Rd, Clifton, N. J.*

For more information circle **295** on inquiry card.

Capacitance and Inductance Testers

New "FT-KARU Capacitance Meter" and "FT-LARU Inductance meter" for plant or lab uses offer complete coverage of commonly encountered component values; feature new error-reducing controls and gear-linked selector switches and slide rule dials providing rapid bandswitching and parallax-free direct reading. Selection of a given range on either instrument automatically brings corresponding scale into viewing window. Capacitance Meter covers range of 0.5uuf to 10uf in seven steps, holding to ±1% + 0.5uuf within entire range. Inductance Meter covers 0.1uh to 1 h with accuracy of ±1% + 0.01-uh. Self-resonant frequency of coils and other tuned circuits can be measured directly. Both instruments measure 12" x 8¾" x 8¾" and each weighs 16 lb.—*Instrument Div., Federal Telephone and Radio Co., 100 Kingsland Rd., Clifton, N.J.*

For more information circle **296** on inquiry card.

Volt-ohm-Milliammeter

New "Model 455" is said to "incorporate the greatest achievement in VOM history": protection against ac-

NOW OMNIGUARD...
Can Increase Production
...through low-cost insurance against down time

Whenever conditions call for prolonged, full capacity operation, critical temperatures can cause bearing failure – and result in ruinous shutdowns.

Increased temperature also shortens bearing life expectancy, before causing actual failure – another costly factor in the long run.

This is where the Edison Omniguard comes in – and where it pays its way many times over.

Omniguard's central monitor panel keeps *one* operator constantly posted on bearing temperatures in every plant unit . . . allows running at peak loads with safety.

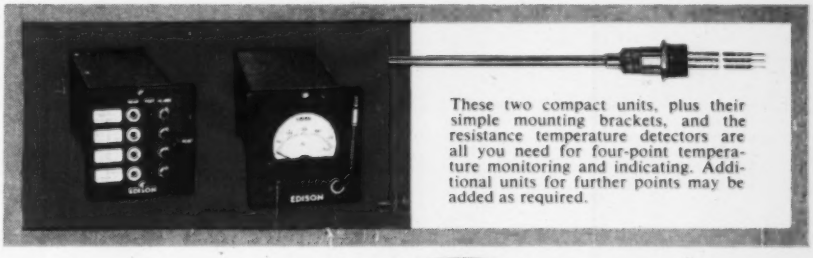
And full capacity operation can be maintained longer – because Omniguard sounds its warning before the damage level is reached.

You can trust Omniguard - because

- Entire system has no moving parts only simple *electrical* circuits, nothing to wear out.
- No adjustments or maintenance necessary – and installation costs are so low because only a minimum of wiring is required.
- Resistance Temperature Detectors are guaranteed accurate to ± 1% – drift less than ± .05%.

And Edison Omniguard costs so little . . . upwards of 50% less than any other monitoring system. This is truly the lowest cost insurance against down time–and Omniguard is so flexible – protects small or large plants with equal ease for an initial investment of less than $500.00.

Write today for article that shows how just a small increase in temperature can cut bearing life in half.



These two compact units, plus their simple mounting brackets, and the resistance temperature detectors are all you need for four-point temperature monitoring and indicating. Additional units for further points may be added as required.

Thomas A Edison

A GREAT NAME CONTINUES GREAT NEW ACHIEVEMENTS

Thomas A. Edison

INCORPORATED

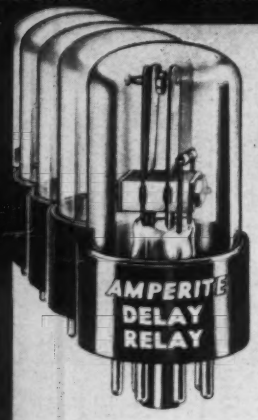
INSTRUMENT DIVISION • 24 LAKESIDE AVENUE • WEST ORANGE, NEW JERSEY

For more information circle **78** on inquiry card.

AMPERITE

THERMOSTATIC
DELAY RELAYS

Provide delays ranging from 2 to 150 SECONDS



STANDARD

MOST COMPACT
MOST ECONOMICAL
HERMETICALLY SEALED

- Actuated by a heater, they operate on A.C., D.C., or Pulsating Current.
- *Hermetically sealed.* Not affected by altitude, moisture, or other climate changes.
- Circuits: *SPST only*—normally open or normally closed.

Amperite Thermostatic Delay Relays are compensated for ambient temperature changes from —55° to + 70°C. Heaters consume approximately 2 W. and may be operated continuously.

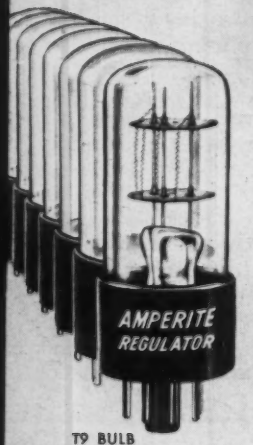
The units are *most compact, rugged, explosion-proof, long-lived,* and — *inexpensive! TYPES:* Standard Radio Octal, and 9-Pin Miniature.

MINIATURE

PROBLEM? Send for Bulletin No. TR-81

Also—a new line of **Amperite Differential Relays** — may be used for *automatic overload, over-voltage, under-voltage* or *under-current protection.*

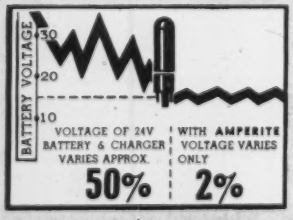
BALLAST REGULATORS

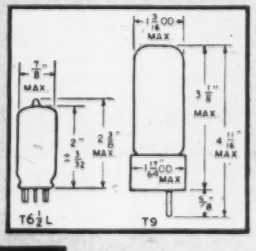


T9 BULB

- Amperite Regulators are designed to keep the current in a circuit ***automatically regulated*** at a definite value (for example, 0.5 amp).
- For currents of 60 ma. to 5 amps. *Operates on A.C., D.C., or Pulsating Current.*
- Hermetically sealed, light, compact, and most inexpensive.

Amperite Regulators are the simplest, most effective method for obtaining ***automatic regulation*** of current or voltage. ***Hermetically sealed,*** they are not affected by changes in altitude, ambient temperature (—55° to +90°C), or humidity. Rugged; no moving parts; changed as easily as a radio tube.





AMPERITE CO., Inc.
561 Broadway, New York 12, N. Y.
In Canada: Atlas Radio Corp., Ltd., 560 King St., W., Toronto 2B

Write for 4-page Technical Bulletin No. AB-51

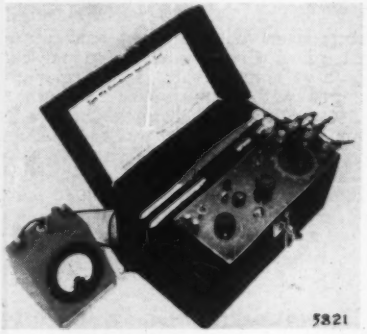
For more information circle **70** on inquiry card.

cidental burn-outs: in event a dangerous over-load is applied, instrument disconnects itself and raises a reset button on case. Two models: "Industrial Model 455," sensitivity of 20,000 ohms per volt ac or dc; "Audio Model 456," sensitivity of 20,000 ohms per volt dc and 1,000 ohms per volt ac; also db ranges and provisions for output measurements.—*Hickok Electrical Instrument Co., 10519 Dupont Ave., Cleveland 8, Ohio.*

For more information circle **297** on inquiry card.

Ground-resistance Tester

New "Type W4 Groundmeter" is a null-method Wheatstone bridge for measuring resistance to ground of


5821

driven ground rods, buried piping systems, etc. Ranges 1/5/10/50/100/500/1000/5000/10,000 ohms; operated by six ordinary flashlight cells; can also be used as a dc Wheatstone bridge from 0.01 ohm to 100,000 ohms at 0.1% accuracy by connecting an external dc galvanometer.—*Borden Engineering Co., 39 East Hanover Ave., Morris Plains, N. J.*

For more information circle **298** on inquiry card.

High-precision VDR and VDR Checker

5809

New "MP-10 Master Potentiometer" features independent linearities of 40 and 20 parts per million with dc excitation and a Comparison Standard accurate to 1 ppm. It is said to be the world's most accurate commercially available voltage-dividing resistor. Electrical rotation 3600° +1° —0°; standard mechanical rotation 3780° ±4°; available in 5- to 200-kilohm values, in various models. ★New "Potentiometer Checker" compares 1-, 3-, 10- or 15-turn VDRs with "MP-10" and plots deviations on a strip-chart.—*Analogue Controls Inc., 37 W. 20th St., New York 10, N. Y.*

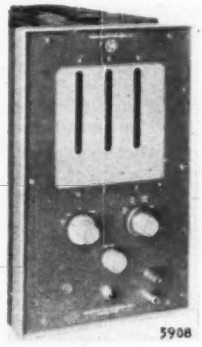
For more information circle **299** on inquiry card.

Amplitude Modulator

New "Model 115" operates over frequency range of 0.1 to 50 Mc with external modulation frequencies of 30 cps to 15 kc; provides 100% AM with low envelope distortion and negligible incidental FM; can be used with any conventional AM or FM signal generator and an audio oscillator capable of producing about 10 v across 100,000 ohms. Weight 15 lbs.—*Measurements Corp., Boonton, N.J.*

For more information circle **300** on inquiry card.

Digital-display Tester



New "Model 503 Digital Multitester" measures dc volts, ac volts and ohms, uses three columns of electronic decade counters with neon light display as indicator. Accuracy on dc range is 0.15% of full scale, on ac 1% and on ohms 0.2%. Ranges 0.01 to 1000 volts and 10 ohms to 10 megohms.—*Laboratory for Electronics, 75 Pitts St., Boston 14, Mass.*

For more information circle **301** on inquiry card.

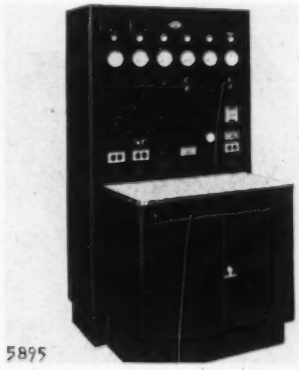
Sweep Generators

New "Model HFS-1319 Broadband Sweep Generator" simultaneously displays frequency range of 1350 to 1950 Mc; "Model HFS-813" displays 845 to 1375 Mc. Both yield a wide panoramic display enabling rapid design, alignment and test of systems and components within L Band. Typical Tschebycheff or Butterworth response curves are available at engineer's discretion.—*Applied Research, Inc.*, 163-07 *Depot Rd., Flushing, N. Y.*

For more information circle **302** on inquiry card.

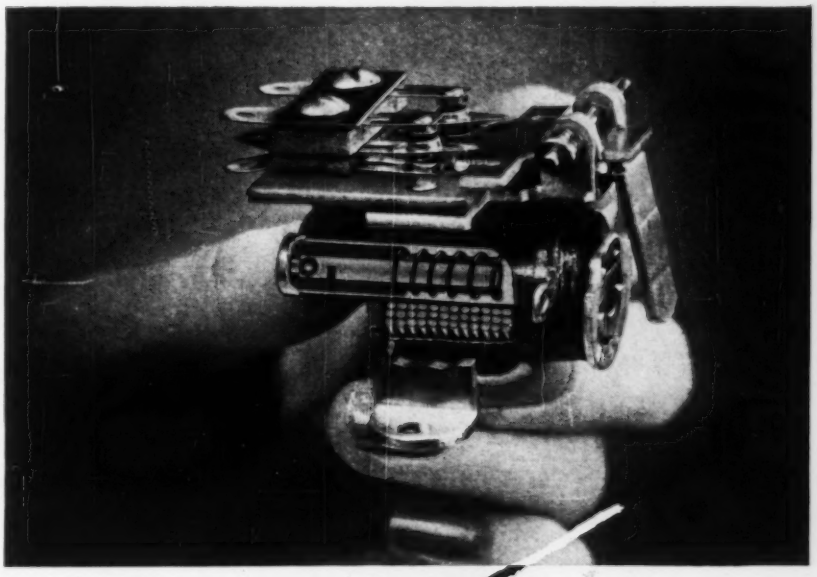
Multipower-source Stand

New multipower source stand can simulate any combination of aircraft electrical conditions; provides (1)



variable dc voltage from 5 to 32 with 200 amps maximum; (2) variable 60-cps voltage from 0 to 135 with 20 amps maximum; (3) variable voltage from 95 to 135 with variable frequency from 380 to 420 cps.—*Industrial Engg. Corp., 525 E. Woodbine, Louisville 8, Ky.*

For more information circle **303** on inquiry card.



NEWEST PRINCIPLE

No wonder the new Silic-O-Netic Time Delay Relay has aroused such interest. It offers basic advantages as a delay device unequalled in its low price range.

The Silic-O-Netic Relay provides delay with no mechanical linkages . . . no mechanism to speak of. . . only one moving part, and that part is hermetically sealed, forever free of dirt and dust. It operates on a positive change in magnetic flux which is sharply defined as the movable core touches the pole piece. Moreover, the new Type A model has high speed contacts, affords good contact pressure.

in TIME DELAY RELAYS

Heinemann Silic-O-Netic Relays are already being used in dozens of volume applications where absolute dependability is essential. They are well worth your investigation.

Write for Bulletin T-5002

IT'S DIFFERENT...

No thermal elements . . . no aging, no fatigue . . . long-life stability.

Small size . . . Overall dimensions: 2 1/16" x 1 9/16" x 2".

Delay periods . . . ¼ to 120 seconds.

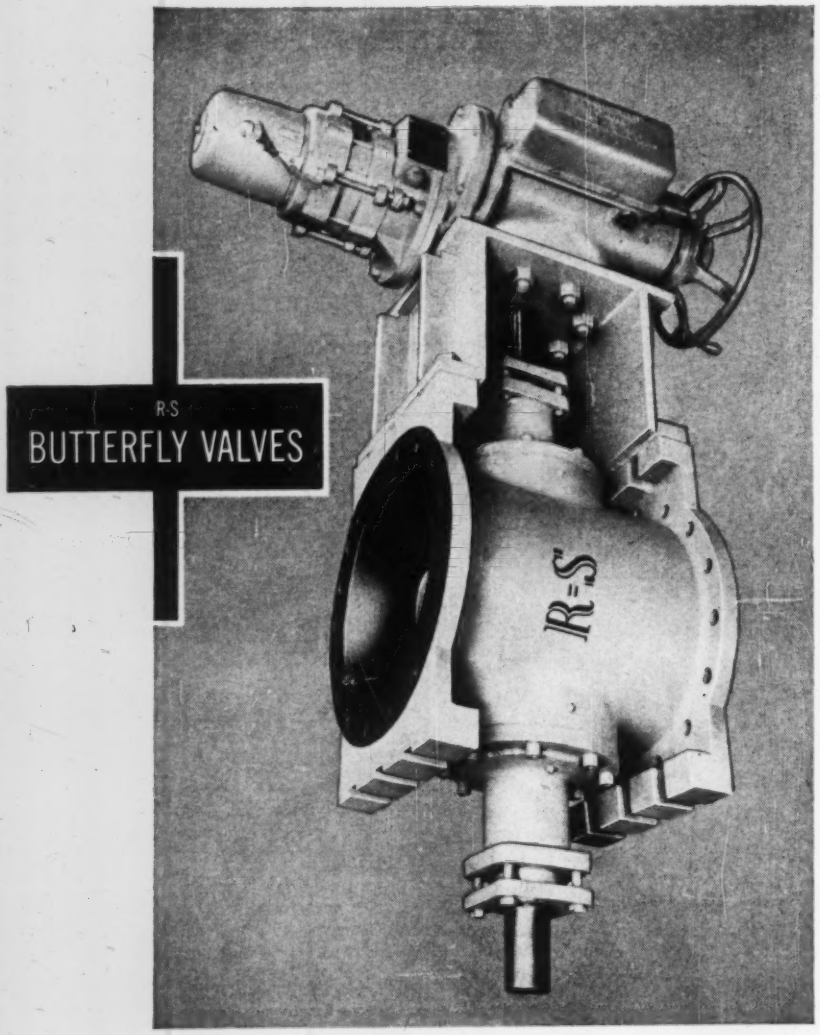
Low cost . . . achieved in 20 years of solenoid manufacturing experience.

HEINEMANN

ELECTRIC COMPANY

160 Plum St., Trenton 2, N. J.

For more information circle **71** on inquiry card.



SPECIAL R-S VALVES RESIST CORROSION...ABRASION...HEAT

Where rugged processing conditions call for special handling, R-S Butterfly Valves are designed and built to meet individual requirements. Any type of metal or other material that can be cast or welded—even plastics—may be specified for valve bodies or parts.

Special metals have been developed to withstand corrosion, abrasion, erosion, high heat and pressure. For certain types of corrosion, the R-S Rubber-lined Valve may be used. Every R-S Valve gives you the advantages of quick and positive closure with any type of controls, uniform control in normal regulating range, and minimum pressure drop to save power.

When past experience offers no precedent, you can draw on our background in specialized valve engineering to solve material problems. To find the proper valve for any application, or for full information on our full line of butterfly, cone and ball valves, write to S. Morgan Smith Company, York, Pennsylvania.

Hydraulic Turbines
Pumps
Gates & Hoists
Trash Rakes
Accessories
HYDRODYNAMICS
Rotovalves
Ball Valves
Butterfly Valves
Free-Discharge Valves
Controllable-Pitch Ship Propellers

S. MORGAN SMITH CO.

AFFILIATE: S. MORGAN SMITH, CANADA, LIMITED, TORONTO

For more information circle **72** on inquiry card.

ELECTRICAL INSTRUMENTS

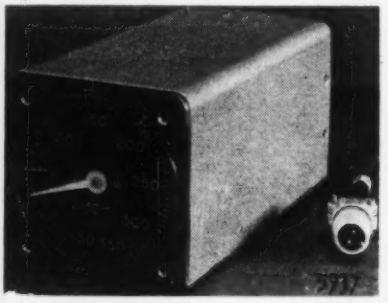
Microammeters

New "Hoyt No. 647 D. C. and No. 648" ac and dc microammeters for industrial panel installations feature smoothly finished black Bakelite cases unaffected by industrial fumes or high temperatures; are available with provision for bottom illumination and have standard 4" x 3-9/16" mounting stud dimensions.—*Burton-Rogers Co., 42 Carleton St., Cambridge 42, Mass.*

For more information circle **304** on inquiry card.

Aircraft Potentiometer

New "Model EMP-NS2 Self Balancing Potentiometer" weighs 3 lbs; operates from a single power source and, since it requires no additional

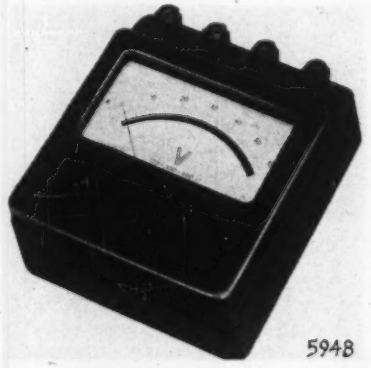


power supply units or amplifiers, is a third as large as comparable instruments. Any temperature range between −60°F and 2000°F or comparable C; can accurately indicate fast-changing temperatures during flight. Or, instead of temperatures, readings of outputs of strain gages, accelerometers, etc., to be observed by a pilot or recorded photographically.—*North American Aviation, Inc., International Airport, Los Angeles 45, Calif.*

For more information circle **305** on inquiry card.

Precision Instruments

New C. P. Goerz (Vienna) precision (0.5%) instruments include moving-coil ammeters, milliammeters, mi-



croammeters, galvanometers, voltmeters and high-sensitivity millivoltmeters and electrodynamometer single- and three-phase (3- and 4-wire) wattmeters. All units have mirror scales and knife-edge pointers.—*Physics Research Labs., Inc., 507 Hempstead Turnpike, West Hempstead, N. Y.*

For more information circle **306** on inquiry card.

Differential Voltmeter

New "Type 1560" measures differences in voltage levels as low as 0.01% regardless of their phase rela-

tion. Because of its excellent stability and high sensitivity, it can also be used to observe drift in amplifiers, instruments, etc. Difference voltage range: −10% to +5% in 0.01% increments. Input voltage levels: from 0.1 to 100 v. Frequency range: 30 cps to 20 kc.—*Freed Transformer Co., Inc.*, 1715 *Weirfield St., Brooklyn* 27, *N. Y.*

For more information circle **307** on inquiry card.

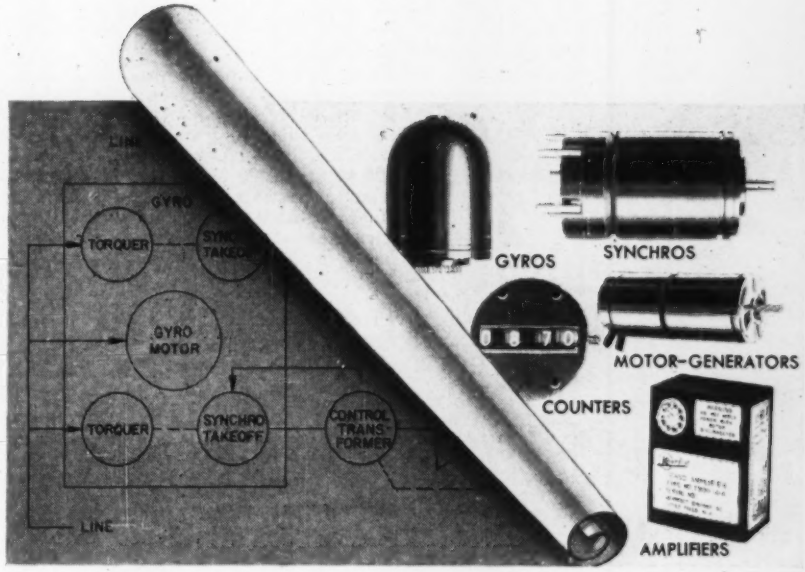
Amplifier-Voltmeter

New "Type 346 Sensitive Amplifier-Voltmeter" is a compact and highly sensitive VTVM which can make precise measurements of ac signals from 100 uv to 300 v at frequencies from 10 cps to 2 Mc; also has an output connection permitting it to be used as a broadband amplifier; gives decibel readings from −72 to +52 db (1 milliwatt into 600 ohms reference). Calibration is in two linear voltage scales (0-1 and 0-3) and a decibel scale (−12 to +2 dbm).—*Technical Products Div., Allen B. Du Mont Labs., Inc.*, 760 *Bloomfield Ave., Clifton, N. J.*

For more information circle **308** on inquiry card.

Frequency Meter

New "Model 591 Heterodyne Frequency Meter" (Military type AN/URM-32) features 0.01% accuracy;



KEARFOTT

. . . from problem through production

Engineering ability and production facilities are as important to you as the characteristics of the components you select. After components are approved, you are dependent upon your supplier . . . dependent upon him for engineering assistance . . . dependent upon his ability to produce quality products in the required quantities.

Many of the servo motors, synchros, gyros and systems in use today had their inception on the drafting boards of Kearfott's engineers. This is proof of Kearfott's engineering ability. Kearfott offers complete engineering service before, during and after the purchase of a component.

Modern buildings, over 430,000 square feet of floor space, equipped with the latest in precision machinery, manned by 3,400 highly skilled specialists, are your assurance of Kearfott's ability to produce.

Yes, Kearfott is a dependable source of supply. If you have a design problem or require a special or standard component, contact Kearfott.

KEARFOTT COMPONENTS INCLUDE:

Gyros, Servo Motors, Synchros, Servo and Magnetic Amplifiers, Tachometer Generators, Hermetic Rotary Seals, Aircraft Navigational Systems, and other high accuracy mechanical, electrical and electronic components.

Send for bulletin giving data of components of interest to you.

Kearfott

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West Coast Office: 253 N. Vinedo Avenue, Pasadena, Calif.

For more information circle **73** on inquiry card.

uses three fundamental frequency ranges and their selected harmonics to measure frequencies between 10 kc and 1000 Mc; can generate a standard frequency voltage between 125 kc and 1000 Mc or accept a signal from an external source of 10 kc to 1000 Mc and compare it with either a calibrated variable frequency oscillator or a quartz crystal oscillator. Signals below 125 kc are measured by use of their harmonics.—*Radio Frequency Labs., Inc., Powerville Road, Boonton* 13, *N. J.*

For more information circle **309** on inquiry card.

Vacuum-tube Voltmeter

New "Type 800-B" VTVM for extended-range voltage, resistance, and current measurement is said to combine inherent accuracy of basic voltmeter with a highly degenerative amplifier circuit providing voltage transfer at a high input impedance level that results in negligible disturbance of circuit to be measured. Unique circuitry also achieves long-term stability by eliminating tube-aging problem and effect of fluctuations of meter coil resistance.—*Technology Instrument Corp.*, 531 *Main St., Acton, Mass.*

For more information circle **310** on inquiry card.

ELECTRICAL-INSTRUMENT ACCESSORIES, AMPLIFIERS, POWER SUPPLIES, etc.

"Pocket-size" Precision Resistance Decade

New "Series 1000 Vari-Plug Resistance Decade" consists of extremely accurate (1% to 0.01%) resistances encapsulated in epoxy-resin, adjustable by interlocking shock-proof plug-in connectors, instead of switches. Unique design permits provision of a thermometer well for measurement of temperature rise of individual resistances. Dimensions 2¾" diam x 2½"; weight barely 8 oz; can be panel mounted. Available in several ranges of resistance and accuracy to meet wide variety of uses: laboratory standards, computer aids, and also extreme-accuracy voltage dividers.—*Consolidated Resistance Co. of America*, 44 *Prospect St., Yonkers, N. Y.*

For more information circle **311** on inquiry card.

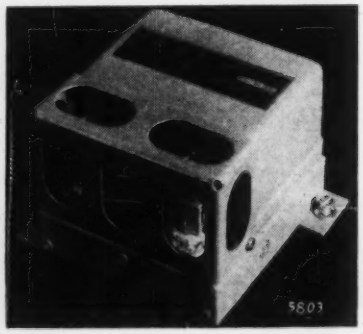
VAM Preamplifier

New "Model 150-2500 RMS Volt/Ammeter Preamplifier" embodies a newly-developed circuit which produces a dc voltage proportional to rms value, thus overcoming limitations of excessive power drain and sluggish response of an instrument movement in recording the rms value of ac voltages and currents. It plugs into an appropriate driver amplifier power supply unit in any of maker's "150 Series" systems.—*Sanborn Co., Industrial Div.*, 195 *Massachusetts Ave., Cambridge, Mass.*

For more information circle **312** on inquiry card.

Integrating Amplifier

New "Type 40" four-tube electronic integrator for use as a component of electronic analog computers features components specially selected or developed for accuracy and long life; all tubes pre-aged for stability and long life. Storage capacitors of 0.01, 0.04, or 0.05 uf can be charged in four ways. Sensitivity: 100, 25, or 20 v output per microcoulomb input. Output: 1 ma max output current at any output voltage from −100 to +100; 5 ma max output current from −50 to +50 v.—*Airborne Instruments Lab., Inc.*, 160 *Old Country Rd., Mineola, N. Y.*



For more information circle **313** on inquiry card.

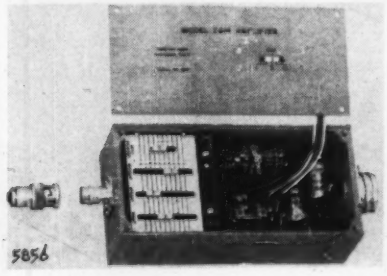
Time-delay Generator

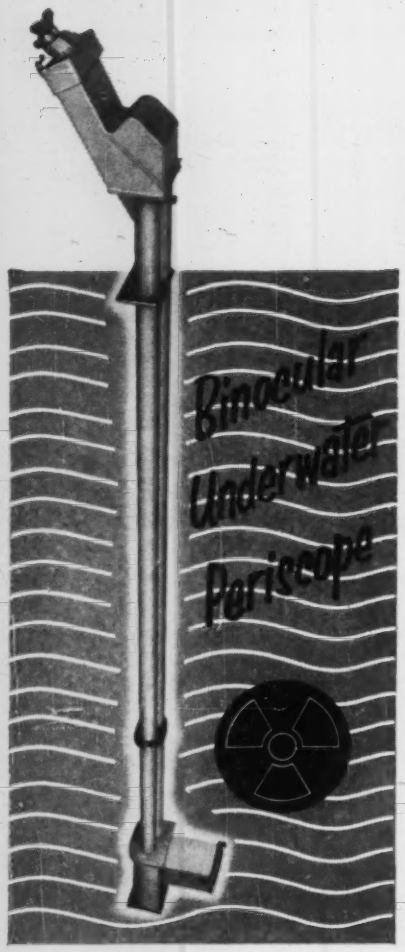
New "Type 326" permits accurate measurement of time functions such as duration of waveforms, pulse widths, etc.; is said to be ideal for use in computer and guided-missile labs. Three overlapping ranges provided delays from 1.5 to 10,000 usec; accuracy better than 0.1% at delays up to 1000 usec and 1% on top range to 10,000 usec; jitter less than one part in 10,000 at any delay setting.—*Technical Products Div., Allen B. Du Mont Labs.*, 750 *Bloomfield Ave., Clifton, N. J.*

For more information circle **314** on inquiry card.

Instrumentation Amplifier

New "Model 2614" probe-type preamplifier for use with piezoelectric pickups permits user to "trim" self-generating pickup output sensitivity





An industrial periscope is very often the answer to hard-to-get-at, underwater, hazardous location or Hot-Spot remote control observation. Ideal for use where heat, pressure or Hot Cell radiation are problems . . . the periscope offers unsurpassed clarity and definition, true color, and a long, maintenance-free service life. Attachments are available for photo recording all viewed material.

With our wide experience in this field, we probably have a design to fit your viewing problem. Send for Bulletin 301

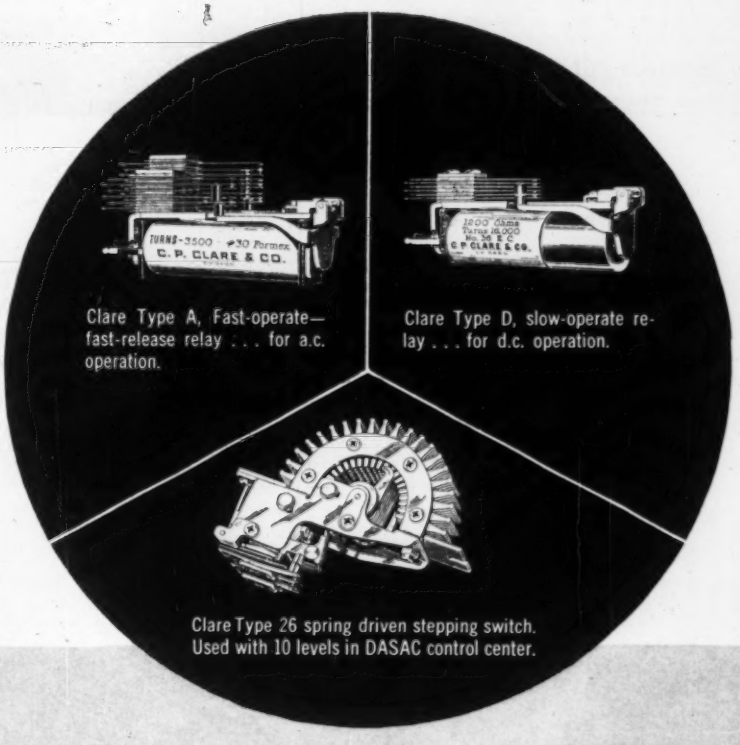
KOLLMORGEN
Optical
CORPORATION

Plant: 347 King Street, Northampton, Mass.
New York Office: 30 Church St., New York 7

For more information circle **74** on inquiry card.

Circle **75** on inquiry card. ⟶

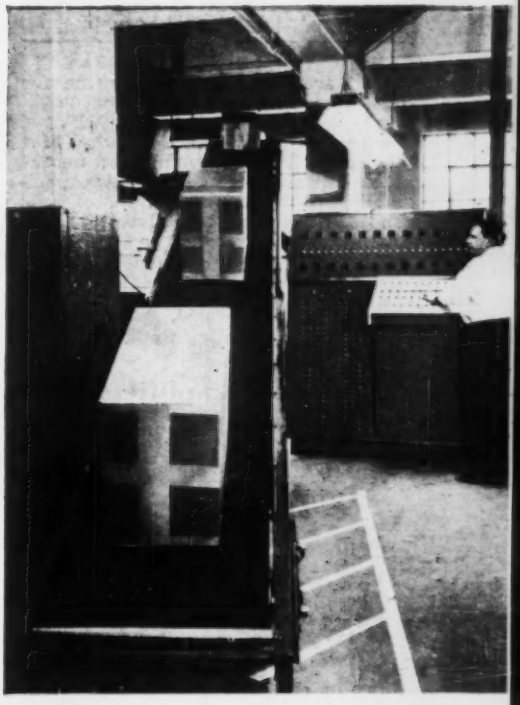
Stability and Reliability make CLARE Relays and Stepping Switches ideal components for DASAC



Clare Type A, Fast-operate—fast-release relay . . . for a.c. operation.

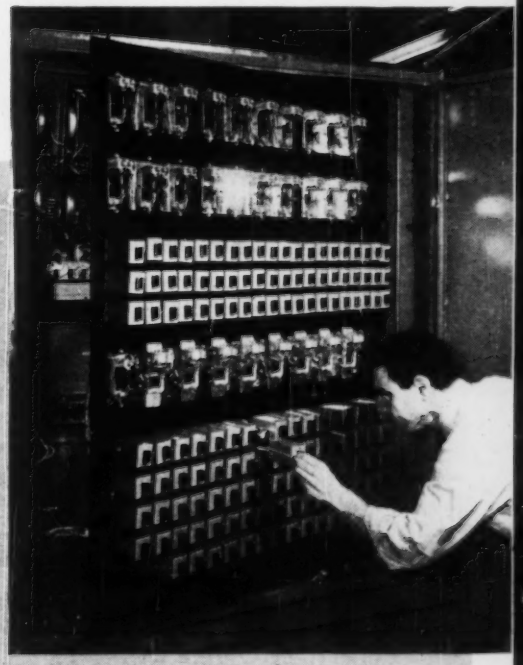
Clare Type D, slow-operate relay . . . for d.c. operation.

Clare Type 26 spring driven stepping switch. Used with 10 levels in DASAC control center.



DASAC Push Button Control Center which uses Clare relays and stepping switches in automatic control of warehouse assorting system.

Rear view of panel shows Clare relays, provided with dust tight covers, accessible for quick inspection and maintenance.



Pushbutton control center of the DASAC warehousing and assorting system makes use of over a hundred CLARE Type A and D relays and CLARE 10 level, 26 point stepping switches.

This device, which speeds and simplifies order picking operations, was developed by New York's Dasol Corporation, consulting engineers, to facilitate the warehouse operations of their client, Judy Bond, Inc., large blouse manufacturer.

The DASAC Control Center performs three basic functions. These include selection of container destination, "memorizing" the selections in consecutive order and coordinating the information to stop the container at its proper discharge point. "Relay requirements," said Sol Tanne, Dasol Chief Engineer, "above all, demanded stability and reliability. They had to be fast-acting, quiet, stable telephone-type relays which could easily be replaced if necessary."

Ability of CLARE Relays to perform millions—in some cases billions—of trouble-free operations has made them increasingly in demand as reliable components for today's high speed devices. If your design calls for long-life, high-quality relays or stepping switches, it will pay you to bring your problem to CLARE. Experienced field engineers are located near you. Contact them or call C. P. Clare & Co., 3101 Pratt Blvd., Chicago 45, Illinois. In Canada: Canadian Line Materials, Ltd., Toronto 13. Cable Address: CLARELAY.

CLARE RELAYS

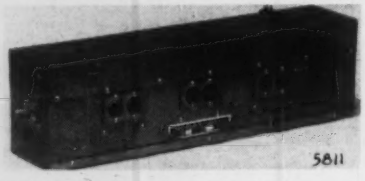
FIRST in the industrial field

to an even or "standard" value for direct reading of acceleration, pressure, etc., with standard VTVMs. Features: input selector switch for choice of 3 input conditions; unique subminiature 3-decade shunt capacitance switch; amplifier gains of 1, 3, and 10; stability 1% of better; frequency response from 2 to 15,000 cps; output 5v into 2500 ohms (source impedance 50 ohms).—*Endevco Corp., Dept. I&A, 180 E. California St., Pasadena, Calif.*

For more information circle **315** on inquiry card.

UHF Amplifiers

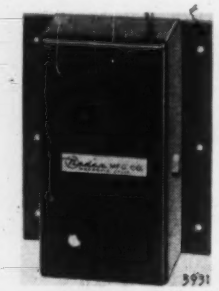
New "Models UH-4(A) and UH-6(A)" amplifiers have a center frequency of 400 Mc. and a bandwidth of



50 Mc; incorporate GL 6299 vacuum tube in lumped-constant triple-tuned circuitry. Power gains are sufficient for new amplifiers' use as either IF amplifiers, or as preamplifiers in order to improve characteristics of existing systems.—*Applied Research, Inc., 163-07 Depot Rd., Flushing, L.I., N.Y.*

For more information circle **316** on inquiry card.

Direct-current Transformer



New transistorized dc transformer is unusually small, completely static; handles an input of 24 to 30 vdc and delivers any dc output. Efficiency is 85%; normal output variation is 8% no-load to full-load; regulation can be supplied within 0.5%.—*Nader Mfg. Co., 2661 S. Myrtle Ave., Monrovia, Calif.*

For more information circle **317** on inquiry card.

Semi-regulated Supplies

New "ELG" semi-regulated power supplies employ germaninum power rectifiers in conjunction with automatic line-regulating transformers and extremely "stiff" transformers and filters. Regulation comparable to conventional circuits is often obtainable (better than 1% against line and load). "Because no electron tubes are used, the supplies are not only extremely dependable and require a minimum of maintenance, but are very efficient." (In most models 94%). Average temperature rise 5C°. Most units can be economically designed for "zero-lag" response.—*NJE Corp., 345 Carnegie Ave., Kenilworth, New Jersey.*

For more information circle **318** on inquiry card.

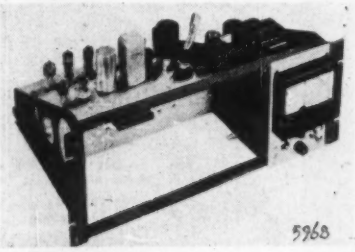
Deviation Indicator

New "Peak Modulation Deviation Meter" has a deviation range of 15 kc full scale, with accuracy of deviation measurement 5% of full scale. It is a completely transistorized unit, built to fit in lower compartment of maker's "FM-3 Frequency Meter" without removing present power supply or batteries; is also available in separate carrying case.—*Gertsch Products, Inc., 11846 Mississippi Ave., Ave., Los Angeles 25, Calif.*

For more information circle **319** on inquiry card.

Amplifier and Supply

New "Model 150-300/700" is a combined wide band driver amplifier and power supply unit, which accommo-



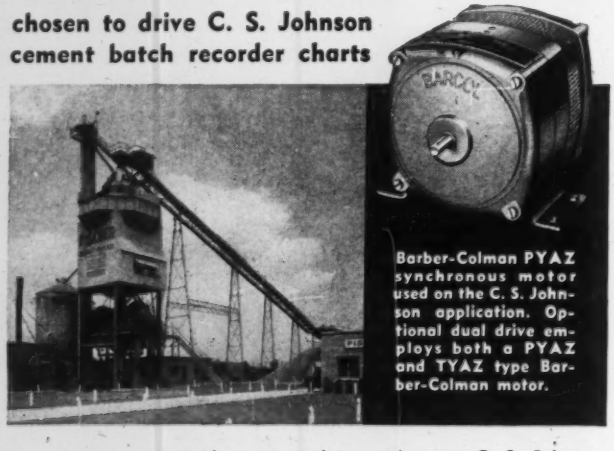
dates any of maker's eleven available interchangeable plug-in "150 Series" preamplifiers. It is intended to drive a low-power galvanometer element, panel instrument and/or CRO, individually or simultanously.—*Sanborn Co., 195 Massachusetts Ave., Cambridge 39, Mass.*

For more information circle **320** on inquiry card.

BARBER COLMAN

Small Motors

chosen to drive C. S. Johnson cement batch recorder charts



Barber-Colman PYAZ synchronous motor used on the C. S. Johnson application. Optional dual drive employs both a PYAZ and TYAZ type Barber-Colman motor.

In its complete line of concrete plant equipment, C. S. Johnson Company, Champaign, Illinois, produces a concrete batch controller with pushbutton operation. This automatic controller provides accurate, rapid change of mixes with graphic recording of materials, date, time, and batch number. To power the paper drive mechanism of the recorder, Barber-Colman small motors were selected. For highly dependable actuation of your products or instruments, too, there is a wide selection of Barber-Colman motors up to 1/20 hp. Unidirectional, synchronous and reversible . . . with or without gearing . . . open or enclosed. Write for data sheets.

Barber-Colman Company

Dept. X, 1215 Rock Street, Rockford, Illinois

For more information circle **66** on inquiry card.

presenting the MODEL P-102

potentiometer

$345.00

AND MILLIVOLT SOURCE

THE MODEL P-102, WHICH INCLUDES A LIGHT BEAM GALVANOMETER, HAS BEEN RUGGEDIZED TO THE EXTENT THAT IT IS COMPLETELY WATERPROOF. ONE HALF THE WEIGHT AND SIZE OF OTHER MODELS, IT IS COMPLETE WITH 4-PLACE WATERPROOF DIGITAL READOUT.

RANGE	0-10.2 MV/0-102 MV.
ACCURACY	0.1% OF RANGE
PRECISION	± .05%
BATTERY LIFE	TWO YEARS
DIMENSIONS	9-1/4 x 9-1/4 x 6-1/2
WEIGHT	10 POUNDS
READOUT	4-PLACE DIGITAL
RUGGED	COMPLETELY WATERPROOF

ALINCO

ALLEGANY INSTRUMENT CO, INC.

Cumberland, Maryland

For more information circle **67** on inquiry card.

differential pressure transducers

For static or dynamic measurement of non-corrosive media

Ranges: ±2.5 to ±25 psid and 0-5 to 0-150 psid

250 psig line pressure rating

Reliable Statham unbonded strain gage transduction

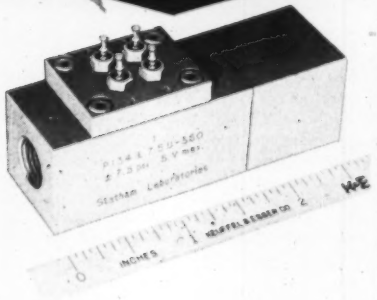
Precisely calibrated with high accuracy potentiometers

Minimum response to vibration or acceleration

20 millivolts at 5 volts excitation

Temperature compensation over 315°F. interval

Sturdy, small in size and light in weight



Model P134 Pressure Transducers for the measurement of differential pressures are described fully in

Bulletin MPT-134
available upon request.

Statham

LABORATORIES

12401 W. Olympic Blvd., Los Angeles 64, Calif.

For more information circle **68** on inquiry card.

Auxiliary Power Supply

New "Model CP" miniature encapsulated power supply withstands the most stringent military environmental specifications; finds wide application with special packages of one- to three-stage vacuum-tube circuits. Dimensions: 2-⅝" x 3-1/16" x 4-¼"; mounting by means of four studs on under surface. Operates from 115-v 60- or 400-cps line; provides two unregulated outputs: 150 vdc at 6 ma and 6.3 vac (center-tapped) at 6 amp. —*Trio Labs; Inc.*, 3293 *Seaford Ave., Wantagh, L. I., N. Y.*

For more information circle **321** on inquiry card.

Miniature Power Supply

New "302C" regulated portable (12½-lb) power supply is said to feature "excellent regulation over a wide voltage range" with less than 3 mv ripple. Standard accessories: dual-scale meter, stand-by switch, pilot light and fuse protection. Over 400 v at 90 ma can be obtained for intermittent periods. A separate bias output is also provided, with independent regulation against line voltage variations. Recovery time better than 15 milisec.—*Allied Engineering Div., Allied International, Inc., South Norwalk, Conn.*

For more information circle **322** on inquiry card.

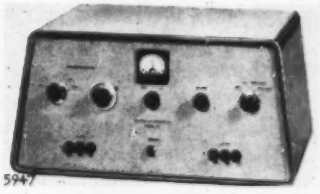
Power Rectifier

New line of selenium power rectifiers is for usual applications, and also for special applications such as laboratory and test purposes, radiation detection equipment, magnetic amplifiers, etc. Cells range in size from 1 x 1 in to 5 x 6 in and with convection cooling are rated from 0.18 to 10 amp per cell on a single phase full-wave bridge basis. Feature: "solid stack" assembly in which all mounted parts are under constant pressure provided by end springs: utmost rigidity and maximum protection against exposure of active areas to corrosion.—*Union Switch & Signal, Pittsburgh 18, Pa.*

For more information circle **323** on inquiry card.

Stabilized Amplifier

New "Model D4" wide-band dc amplifier has a gain of 50,000 with drift referred to input of less than



25 uv/hr. Frequency response dc to 100 kc for gain up to 1000; gain continuously adjustable from 0.001 to 50,000; Accuracy of gain settings 1.5%. Pen or string galvanometer can be driven directly from output.—*Photron Instrument Co., 6516 Detroit Ave., Cleveland 2, Ohio.*

For more information circle **324** on inquiry card.

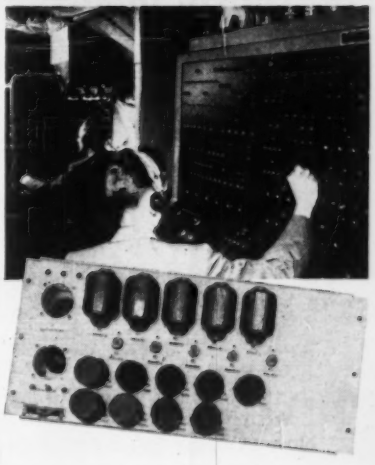
Transistor Power Supply

New "Model T-100A" dc power supply especially engineered to power resistors is useful also in designing transistor circuits and in development

BARBER COLMAN

ultra-sensitive relays

selected for use on Flight Simulators built by Curtiss-Wright



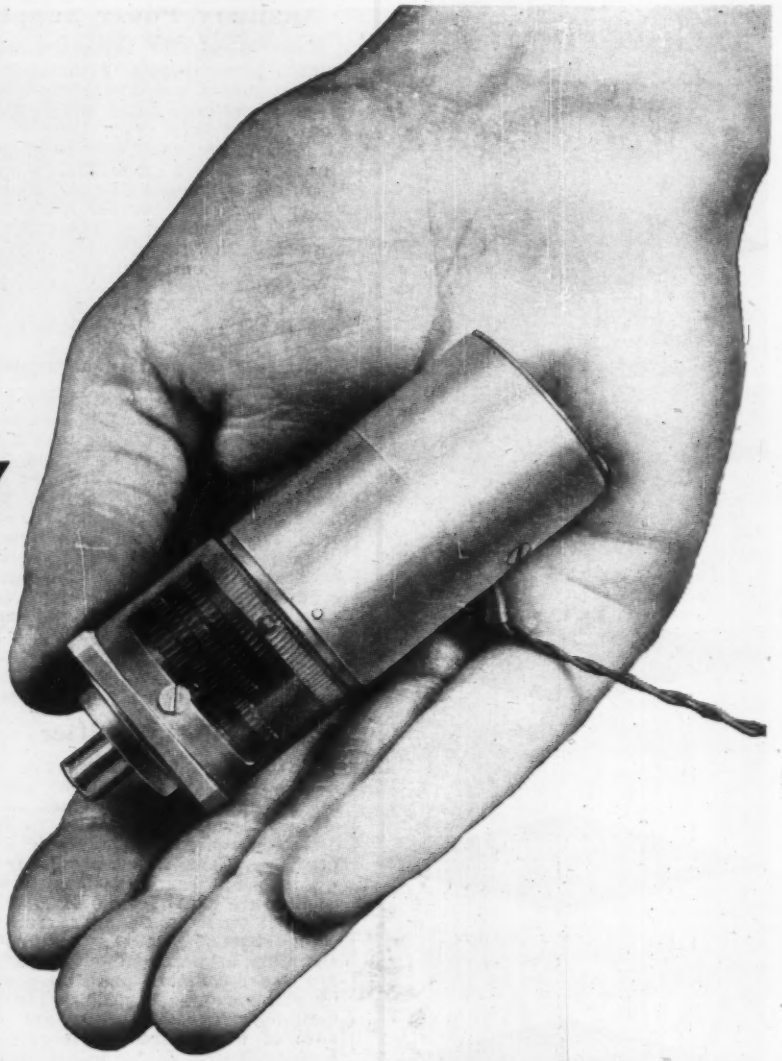
Reproducing in exact detail all the flight characteristics of the giant C-124 troop and cargo carrier, the Electronic Flight Simulator built by the Electronics Division of Curtiss-Wright permits intensive flight familiarization without personnel ever leaving the ground. In this Simulator's generator system, five Barber-Colman Micropositioners are used. In your applications, too, there is very likely a place for this remarkable ultra-sensitive relay. Various types . . . plug in, solder-lug, screw terminal, hermetically sealed. Operate on input powers of 50 to 1,000 microwatts. Ideal for use as a null detector in resistance bridge circuits, a differential relay in electronic plate circuits, and an amplifier in photoelectric circuits. Can be operated in excess of 100 cps. Write for Bulletin F-3961-4.

Barber-Colman Company

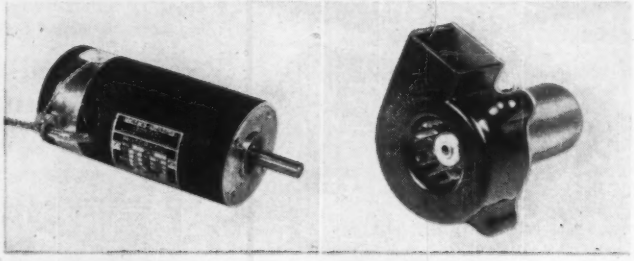
Dept. X, 1415 Rock Street, Rockford, Illinois

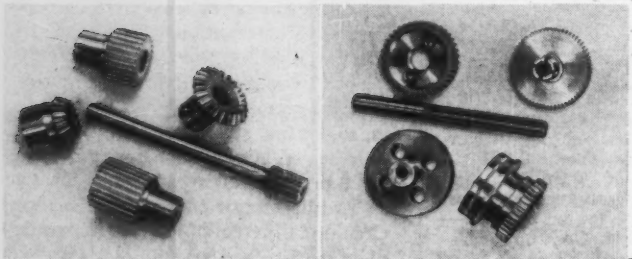
For more information circle **69** on inquiry card.

how to reduce costs with WESTERN GEAR rotary electrical equipment



We have more than 50 basic prototype motors, fans, blowers, converters, alternators and generators. Motor designs range from 1/500th to 4 HP, 50 to 1,000 cycles in frequency, any desired voltage. Extensive line enables economic modification to your requirements or special design. Complete engineering service gladly offered for help on any rotary electrical equipment problem. Write for new catalog No. 254-A.





Precision fine pitch gears, constructed to the highest specifications for electronics use, available from 200 to 6 diametral pitch and from .125" to 10" diameter. Complete engineering and manufacturing facilities for the application of high precision gearing and gear drives in electronics equipment. Ask for help on your problem. No obligation!

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Detail your requirement on any electronic problem. Utilize Western Gear's production facilities to cut your product costs. Our engineers will give their recommendations promptly. Address Western Gear Corporation, Electro Products Division, 132 W. Colorado St., Pasadena 1, Calif.

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ENGINEERS AND MANUFACTURERS

PLANTS AT LYNWOOD, PASADENA, BELMONT, SAN FRANCISCO (CALIF.), SEATTLE AND HOUSTON — REPRESENTATIVES IN ALL PRINCIPAL CITIES

For more information circle **79** on inquiry card.

work on transistors. It is a closely-regulated dual-voltage supply, with both outputs contained in a single chassis suitable for rack mounting or bench use. Cabinet size: 5¼" high, 19" wide, 14" deep. Each output supplies 0-100 vdc continuously variable (without switching), and 0-100 ma maximum. No derating of output current is necessary.—*Dressen-Barnes Corp., 250 N. Vinedo Ave., Pasadena 8, Calif.*

For more information circle **325** on inquiry card.

ELECTRICAL COMPONENTS

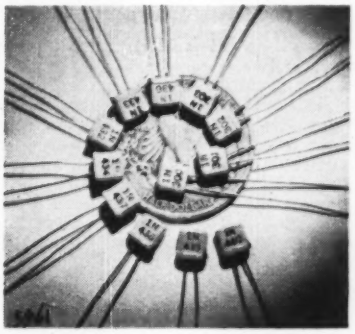
Smallest Transistors

Four new transistors, one-quarter to one-third the size of former units, are *p-n-p* fused-junction germanium transistors with a volume of 0.0087 cu in. Three are intended for use in audio or low-RF applications; the fourth is a low-noise unit for use in low-level audio circuits.—*Raytheon Mfg. Co., 55 Chapel St., Newton 58, Mass.*

For more information circle **326** on inquiry card.

Silicon Diodes

Eight new units complete a line of twelve hermetically-sealed bonded silicon crystal diodes having peak in-



verse voltage ratings from 3.0 to 225 v. Four of these new units are designed for use as voltage references or regulators at voltages ranging from 3 to 11. All offer excellent stability and low reverse current at ambient temperatures from −55°C to +150°C.—*Raytheon Mfg. Co., 55 Chapel St., Newton 58, Mass.*

For more information circle **327** on inquiry card.

Variable Inductors

New "Series 1000" miniature variable inductance coils, covering 1-to-1000 microhenry range completely, are for RF and IF amplifiers, filter networks, etc.; feature ceramic forms, split bushings and locknuts, and single "D" hole type mounting.—*North Hills Electric Co., Inc., 203-18 35th Ave., Bayside 61, N. Y.*

For more information circle **328** on inquiry card.

Resistors for Automation

New Series "A" encapsulated precision wire-wound resistors for use in printed wiring circuits are designed

NEW

PHAOSTRON
NONE FINER

"777"
V. T. V. M.
(VACUUM TUBE VOLTMETER)

The MODEL "777" V.T.V.M. is a completely self-contained, ready-to-use test instrument. Its accessories and the HF co-ax cable, DC Probe, AC line cord and instruction book all fit in the genuine California Saddle Leather carrying case that is furnished with the instrument.

42 Unduplicated Ranges
Illuminated Dial (5000 hour self-contained lamps)
Die Cast Chrome Finished Bezel
Metal Case, unbreakable, ultra compact
Doubly Shielded, time proven 200 microamp movement
Permanent Accuracy . . . 3% DC, 5% AC
Large, Easy to Read Scales 4⅞" Long
Color Coded Scales: green—ohms; black—AC, DC; Red—P. to P.
2 Zero Center Scales for FM Discriminator Alignment
Separate Range and Function Switches
Only 2 Jacks for All Measurements
New, High Style, Easy-to-Use Chrome Bar Knobs
Dual Purpose Handle also serves as AC line cord reel

YOUR KEY TO EXCELLENCE

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"777" V.T.V.M. complete with Coaxial Cable, DC Probes and Leather Case at your PARTS DISTRIBUTOR

$69.95

PHAOSTRON INSTRUMENT AND ELECTRONIC COMPANY
151 PASADENA AVE., SOUTH PASADENA, CALIF.

For more information circle **82** on inquiry card.

No Galling of Threaded Parts When You Use

Swagelok®

GOOP*

New Swagelok Goop thread lubricants are used to eliminate the "welding action" or galling in pulling up threaded parts of stainless steel, nickel, Monel, titanium and aluminum. A light application of Goop to threads so protects them that the threaded parts can be used over and over again.

Swagelok Goop lubricants available in two types:

- Blue Goop for use on titanium, stainless steel and aluminum for temperature ranges up to 400° Fahrenheit.
- Silver Goop for use as an effective antiseize compound for use on stainless steel and high temperature alloys for temperature ranges up to 2,000° Fahrenheit.

Swagelok Goop is made by the Crawford Fitting Company, makers of Swagelok Tube Fittings.

Generous Free Sample

Write today for complete information and a sample tube of Swagelok Goop. Address Dept. A-5.

† M. Patent Applied For

CRAWFORD FITTING CO.
884 E. 140th Street
Cleveland 10, Ohio

For more information circle **44** on inquiry card.

NEW INSTRUMENTS

to conform to specs proposed by RETMA for components to be used in automatic assembly equipment. Tough epoxy plastic is filled with heat-conducting mineral which dissipates heat and equalizes "hot spots" in winding. Sealed-in terminal connections are welded.—*Hycor Co., Inc., 11423 Vanowen St., North Hollywood, Calif.*

For more information circle **329** on inquiry card.

Precision VDR

New "Model 2007" single-turn voltage-dividing resistor features all-aluminum case, front and rear ball

bearings and high-temperature terminals. Up to five units can be ganged on one shaft. Body diameter 1.1". Standard linearity tolerance 0.5%. Resistance values 100 ohms to 100 kilohms. Max number of taps 11.—*William I. Mann Co., 116 W. Foothill Blvd., Monrovia, Calif.*

For more information circle **330** on inquiry card.

Low-cost VDR

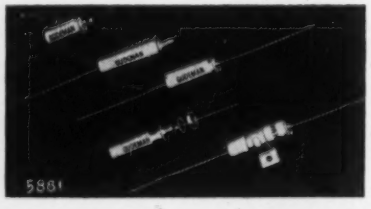
New redesign of "Humdinger" or "Series MH Control provides an increased range of resistance values:

from 2 to 15,000 ohms—a gain of 14,000 ohms over earlier models; features insulated construction, with wiper arm insulated from shaft mounting and bushing.—*Clarostat Mfg. Co., Inc., Dover, N. H.*

For more information circle **331** on inquiry card.

Plastic-film-dielectric Capacitors

New high-temperature "XC" plastic-film-dielectric capacitors feature exceptionally high insulation resistance, low power factor and low dielectric-absorption. Operating tempera-



ture range —65°C to 165°C. Units are hermetically sealed; also meet moisture resistance and vibration specs of MIL-C-25A; withstand a dc voltage 200% of rated voltage for 1 minute at 25°C.—*The Gudeman Co., 340 W. Huron St., Chicago 10, Ill.*

For more information circle **332** on inquiry card.

Teflon-cased Capacitors

New Teflon-cased capacitors are designed for sustained high-temperature operation where high insulation resistance must be maintained. Typical units are rated at 450 vdc for continuous operation at 125° C, maintaining insulation resistance on the order of 10^7 megohms.—*Film Capacitors, Inc., 3400 Park Ave., New York 56, N. Y.*

For more information circle **333** on inquiry card.

Aluminum Electrolytic Capacitors

New "Lyttl-Lytics," said to be "the smallest hermetically-sealed aluminum electrolytic capacitors ever made," are said to be ideal for use in transistorized pocket radio receivers, wireless microphones, personal style wire recorders, etc.; are available in a wide range of capacitance ratings from 1 to 110 uf and in standard working dc voltages of 1, 3, 6, 10, 12, and 15. Sizes range from 3/16" D x ½" L to ⅜" D x ¾" L.—*Sprague Electric Co., 401 Marshall St., No. Adams, Mass.*

For more information circle **334** on inquiry card.

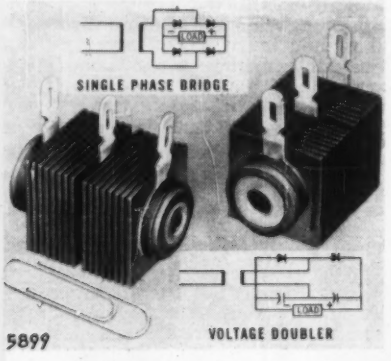
Ceramic Capacitors

New "Type H-A Hi-K Disc Ceramicons" utilize a dielectric said to "exhibit the flattest temperature characteristic Hi-K material ever offered to industry at non-premium prices." Units are available in production quantities in any normal capacitance value from 150 to 4,250 mmf, with tolerances of ±10% and ±20%; diameters from 5/16" to 3/4"; maximum thickness on all units is 5/32"; wire leads or spade leads for automatic insertion in printed-circuit boards.—*Erie Electronics Div., Erie Resistor Corp., Erie, Penna.*

For more information circle **335** on inquiry card.

Selenium Rectifier

New "Type 60-9150" is a small inexpensive dual-purpose selenium rectifier, basically a voltage doubler stack, so that one unit can be used as a doubler and two connected as a single-phase full-wave bridge. It is said to be "ideal for operating equipment in professional and commercial offices



where hum is objectionable." Two units connected in a single-phase full-wave bridge circuit will deliver about 180 vdc at 0.10 amp for an rms voltage input of 230. As a voltage doubler will deliver 50 ma connected to a maximum ac input of 175 v rms. With sufficient capacitance, an output of 350 vdc can be obtained.—*International Rectifier Corp., 1521 East Grand Ave., El Segundo, Calif.*

For more information circle **336** on inquiry card.

ELECTROMECHANICAL COMPONENTS

Light-weight Servomotors

New type of construction of maker's servomotors provides substantial weight reductions and increased cooling efficiency; is available in standard sizes 11, 15 and 18, as well as custom-designed sizes. Many of these units are available for operation on 400-cps supply; some for 60-cps. Stators are embedded in an insulating compound of high dielectric strength and high temperature stability.—*G-M Labs., Inc., 4300 N. Knox Ave., Chicago 14, Ill.*

For more information circle **337** on inquiry card.

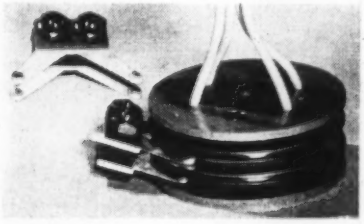
Open-type Aircraft Motor

New "Type A" general-purpose open-type aircraft motor provides a light-weight (3½-lb)) drive for actuators, etc., delivers ¼ hp continuously at 7200 rpm; is designed for 3-phase 400-cps 200-v operation; functions at altitudes up to 40,000 ft.—*U. S. Electrical Motors Inc., Aircraft Div., Box 2058, Terminal Annex, Los Angeles 54, Calif.*

For more information circle **338** on inquiry card.

Ring Assembly

New slip ring and brush assembly for a wide variety of applications obviates need for special design and



engineering, high-cost low-run machining, or special tooling. From two to ten circuits in one assembly, two or more assemblies of ten each stackable together, currents up to 20 amp and extremely low noise levels make new assemblies useful for controls, strain gages, telemetering, etc.—*D. E. Makepeace Co., Attleboro, Mass.*

For more information circle **339** on inquiry card.

Ag-CdO Contacts

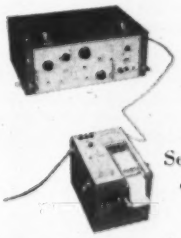
New silver-cadmium oxide electrical contacts will enable manufacturers of a wide range of electrical devices (from household applicances to heavy earth-moving equipment) to cut costs and in many cases secure improved performance. Current-carrying capacity of appliances often can

SANBORN

OSCILLOGRAPHIC RECORDING SYSTEMS

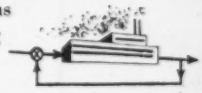
"ON THE JOB"

PROVIDE VALUABLE DYNAMIC ANALYSIS DATA



PRODUCTION TESTING

of components is accomplished by a Servo Component manufacturer by means of a Sanborn Single-Channel Recording System with a Sanborn Servo Monitor Preamplifier.



DYNAMIC PERFORMANCE

of valves when equipped with a certain pneumatic Valve Positioner is determined by the manufacturer with a Sanborn Two-Channel System and Sanborn Carrier Amplifiers.

ACCELERATION and TORQUE

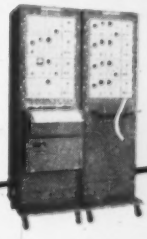
are recorded simultaneously by an oil company in their study of fuels and lubricants as they relate to engine performance.

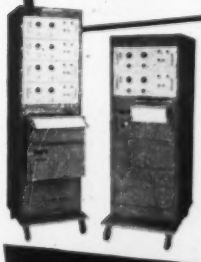
DRONE MISSILE

manufacturer can simulate the flight of the missile and derive information concerning its behavior under certain conditions by means of an analog computer and a Sanborn Four-Channel System with four Sanborn AC-DC Preamplifiers.

ATOMIC REACTOR

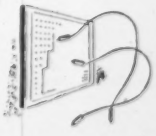
to be used for power generation in prototype plant is studied with the help of a Sanborn Eight-Channel System which records the output of thermocouples, strain gage pressure pickups, and resistance devices.





ANALOG COMPUTING

center uses Sanborn Eight-Channel Systems to record the solutions of problems having six or eight variables. Sanborn systems specially designed for this type of work utilize Dual-Channel DC Amplifiers.



Sanborn 150 Features Include:

Inkless Recording in True Rectangular Coordinates
Preamplifier Interchangeability
Eleven Types of Preamplifiers
Improved Over-all Linearity
Accessibility of Chart During Recording

INDUSTRIAL DIVISION

SANBORN COMPANY

CAMBRIDGE 39, MASSACHUSETTS

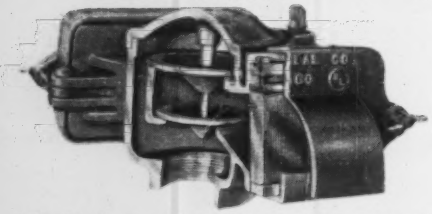
For more information circle **90** on inquiry card.

PROTECTOSEAL
vapor conservation
vents

DESIGNED FOR . . .

LOW-COST MAINTENANCE

FULLY FIRE PROTECTIVE
SIMPLE and **EASY** to
MAINTAIN



Simplified, one-piece design locates flame arrester outside pressure-tight housing where it is easily accessible.

Vertical position of arrester permits condensate to drain off freely—prevents frequent "clog-ups" and prolongs operating time.

Modern "swing-bolts" permit quick removal of vent covers for visual inspection or removal of valves or arresters for cleaning.

Interchangeable arresters permit a spare to be inserted quickly and easily to safeguard tank while servicing original arrester.

Sturdy arrester plates resist distortion during cleaning and are self-positioning to assure correct air-space-gauging and safe reassembly to original Factory Inspection Standards.

Precision fabricated valves are processed to assure tight seatings, and are available as specified on order for other than normal pressure settings. Stream-lined design assures maximum air-flow capacities and self-drainage of condensate.

See our Exhibit-Booth C-38
Exposition of Chemical Industries
West Coast Warehouse: Los Angeles, Calif.
In Canada: Safety Supply Co., Toronto.

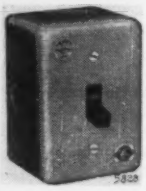
The Protectoseal Company
1954 So. Western Ave., Chicago 8, Ill.
Please send me "Venting Fundamentals"
Name_____ Title_____
Company_____
Address_____
City_____ Zone___ State_____

For more information circle **46** on inquiry card.

be considerably increased, perhaps doubled, through use of new contacts, because they have less tendency to weld together than do usual silver type—*The H. A. Wilson Co., Union, New Jersey.*

For more information circle **340** on inquiry card.

Toggle Switch Starters



New "Bulletin 6002 Type RL" toggle-switch-operated starters, for manual across-the-line starting of small single-phase ac motors, are available in single or double-pole types for a maximum of 220 v 25 to 60 cps; feature bimetallic thermal overload protection with interchangeable heaters covering entire range of starters.—*Clark Controller Co., Cleveland 10, Ohio.*

For more information circle **341** on inquiry card.

Sampling Switch

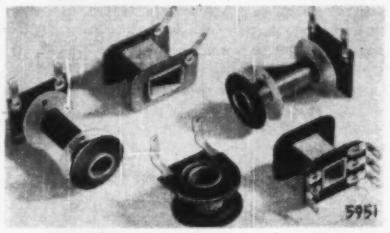
New high-speed precision sampling switch with integral motor and planetary gear reduction is available with

1, 2, or 3 concentric poles, 60 contacts per pole. Connections to each pole are made by convenient-length wire leads molded into plate and attached to multi-pin connectors. This provides plug-in connection and ease of inspection.—*General Devices, Inc., P.O. Box 253, Princeton, N. J.*

For more information circle **342** on inquiry card.

Coil Bobbins

New coil bobbins with any desired number of lug terminals attached can be supplied at low unit cost through



use of maker's high-production-rate equipment. Attached-lug feature adapts bobbins for use with printed circuits. Bobbins can be insulated from coil winding by washers as an integral part of assembly.—*Precision Paper Tube Co., 2035 W. Charleston St., Chicago 47, Ill.*

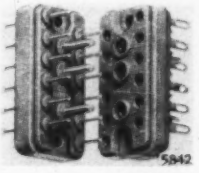
For more informaiton circle **343** on inquiry card.

Directional Couplers

Four new models of wide-band coaxial directional couplers cover range of 225 to 4000 Mc, each covering a full octave and available in 20- or 30-db coupling values. Frequency range is so divided that each coupler covers complete range of most-widely-used bands. Directivity higher than 20 db over full band. Type N female connectors on both ends of primary line and output end of secondary line (other end has built-in coaxial termination).—*The Narda Corp., Mineola, N. Y.*

For more information circle **344** on inquiry card.

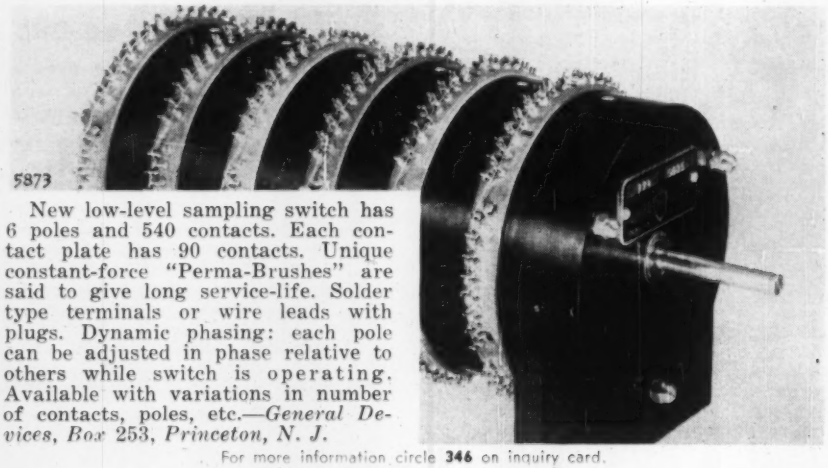
15-point Connector



New 15-contact rectangular "Continental Connector" is added to "GS" Series. Plug has twelve 0.040" diam pin contacts and three 0.090" diam center polarizing contacts molded into a mineral-filled mica phenolic body. Aluminum hoods optional; provide positive cable support and strain relief.—*DeJur-Amsco Corp., Long Island City 1, N. Y.*

For more information circle **345** on inquiry card.

Low-level Sampling Switch

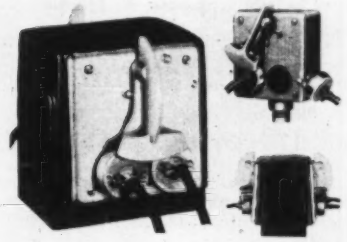


New low-level sampling switch has 6 poles and 540 contacts. Each contact plate has 90 contacts. Unique constant-force "Perma-Brushes" are said to give long service-life. Solder type terminals or wire leads with plugs. Dynamic phasing: each pole can be adjusted in phase relative to others while switch is operating. Available with variations in number of contacts, poles, etc.—*General Devices, Box 253, Princeton, N. J.*

For more information circle **346** on inquiry card.

Safelock Receptacles

New multi-purpose safelock receptacles eliminate dangers of fire and explosions caused by sparking. Exten-



sion cord sets are securely locked into sockets and cannot be removed or inserted until trip lever is actuated, thereby deenergizing socket. Heavy-duty mercury-to-mercury sealed contactors automatically operate as a circuit breaker, obviating need for external switches to receptacle outlets.—*Industrial Automation Corp., 2415 W. Montrose Ave., Chicago, Ill.*

For more information circle **347** on inquiry card.

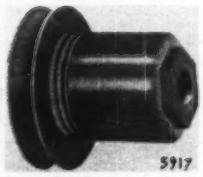
MECHANICAL COMPONENTS

Gear Boxes

New precision gear boxes with a wide range of gear ratios (4:1 to 12,000:1) are designed to mount directly to small electric motors; can also be supplied with an input shaft. "Series 145" provides up to 150 oz-in of torque; "Series 167" 200 oz-in. Weights range from 2½ to 5 oz. Precision ball-bearings are used throughout. Sealed permanently-lubricated bearings are used on output stage. With input gear locked, maximum backlash measured at output shaft is 1°. Units are also available in BuOrd sizes 15 and 18.—*Southwestern Industries, 5880 Centinela Ave., Los Angeles 45, Calif.*

For more information circle **348** on inquiry card.

Variable-speed Pulley



5917

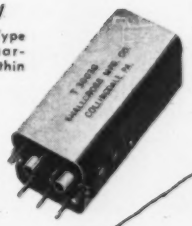
New "E-1350" 3"-diam ¼-hp variable-speed pulley for limited space applications can be mounted with belt take-off close to motor and/or reversed, in which case belt take-off is in an overhung position away from motor. Speed ratios up to 2 to 1. Maximum bore ⅝" with keyway.—*Lovejoy Flexible Coupling Co., 4907 W. Lake St., Chicago 44, Ill.*

For more information circle **349** on inquiry card.

Bevel-gear Unit

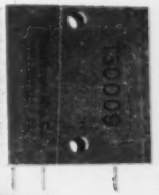
New 2½-hp "ANGLgear" right-angle bevel gear unit with high load capacity is available in either 2-way or 3-way transmission styles; has "Coniflex" bevel gear teeth utilizing principle of localized bearing and maintenance of broad contact, whence

for COLOR TV
Distributed-Constant Type T 30036. Phase characteristics linear within 5% to 4 mc.



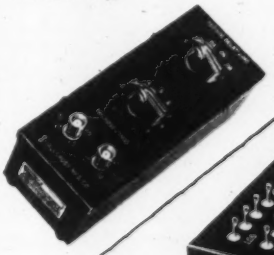
for GUIDED MISSILES
Encapsulated multiple-tap Type 384. Stabilized for rugged environments.

for COMPUTERS
Miniature encapsulated plug-in Type T 30009. Only 1¼" wide by 1½" high.

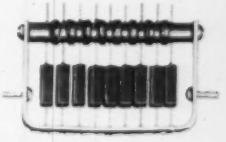


Shallcross DELAY LINES

for LABORATORY DEVELOPMENT
Variable step Type 382. Total delay, 1.1 μs in 0.02 μs steps. Reflections less than 10%.



for RADAR
Multiple-section, open Type 380. Total delay, 0.33 μs with 0.04 μs taps.



for COMMERCIAL INSTRUMENTATION
Enclosed Type T 30030. Total delay, 1.5 μs with 0.05 μs taps.

These six Shallcross lumped-constant and distributed-parameter delay lines cover a wide variety of pulse, video, and timing circuit requirements.

Typical specifications are shown above. Modifications of total delay, tap delay, rise time, attenuation, impedance, bandwidth, dimensions, and mounting are readily possible to match individual requirements exactly.

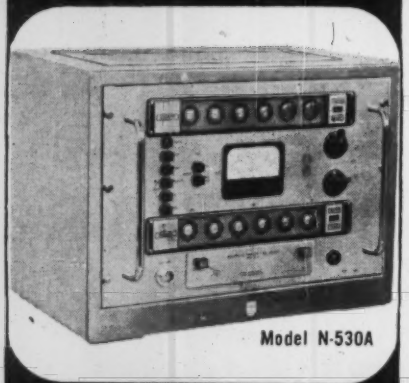
For detailed specifications and dimensions of basic types, send for Bulletin L-38. A copy of Specification Sheet SS-7 will also be enclosed so you may fully outline your delay line requirements for a prompt recommendation by Shallcross Engineers.

Shallcross

MANUFACTURING COMPANY
510 Pusey Avenue, Collingdale, Pa.

For more information circle **86** on inquiry card.

AUTOMATIC ELECTRONIC
DECADE SCALER
AND TIMER
for optimum speed
and accuracy


Model N-530A

The simplicity and accuracy of Dekatron counting and timing circuits make the **Ekco Model N-530A** Automatic Scaler the most outstanding and most versatile instrument of its kind. This scaler will time a pre-determined count, count for a pre-determined time, or can be manually operated.

FEATURES:
- Preset elapsed time interval—100-100,000 seconds in 10ths
- Preset elapsed count interval—100-1,000,000 counts
- Maximum counting rate—60,000 counts/second
- Maximum stopping time—2 milliseconds
- Six electronic decades
- Dekatron direct-reading counting and timing tubes
- Pulse height discriminator permits use with G-M, scintillation, flow or proportional counters—variable 5-50 volt preset acceptance level

SPECIFICATIONS:
- Imput sensitivity—negative 0.1 volt and positive 5 volts
- Input resolution time—5 microseconds, low coincidence loss
- Power Requirements—110-250v, 50/60 cycles, 130 watts
- Dual-range Power Supply—250-1000 and 500-2000 volts

Stability—± 0.5% for variations up to ± 10%.
Ripple—less than 5 mv. rms peak

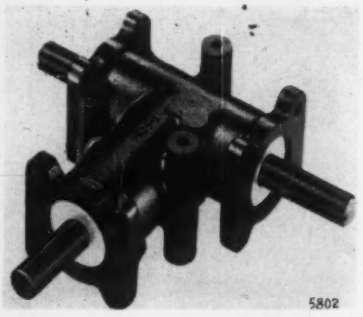
Write TODAY to our American representative for technical data on the complete line of EKCO equipment.

EKCO
ELECTRONICS, LTD.
Southend-on-Sea,
Essex, England

U. S. Sales and Service
AMERICAN TRADAIR CORP.
Long Island City 6, New York

For more information circle **48** on inquiry card.

NEW INSTRUMENTS

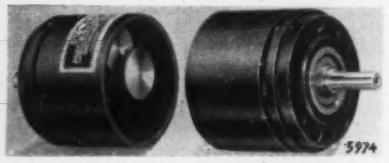

5802

self-adjusting, smooth operation and safe distribution of load. All units are ball-bearing, sealed, lubricated for life.—*Airborne Accessories Corp., Hillside, N. J.*

For more information circle **350** on inquiry card.

Gear Heads

New "600 Series" standard gear heads will fit BuOrd servomotors from 1-1/16" to 1-¾" diam (specials

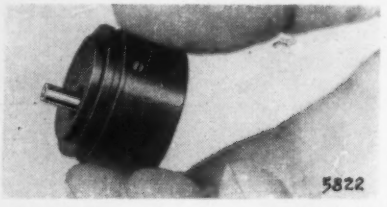

3974

for others); have output shaft concentric with servo mounting diameters.—*Sterling Precision Instrument Corp.*, 34-17 *Lawrence St., Flushing* 54, *N. Y.*

For more information circle **351** on inquiry card.

Gear Head

New "Model 937" subminiature motor gear head, 0.937" D and ⅝" L, has 26.41:1 reduction ratio; can be

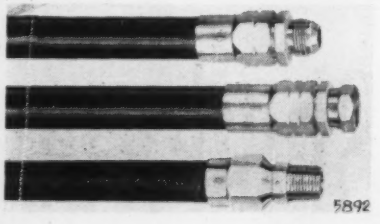

5822

furnished in all practical ratios. It contains, in addition to its gear clusters, a unique adjustable slip clutch. Backlash is less than 30 minutes.—*Bowmar Instrument Corp.*, 2431 *Pennsylvania St., Fort Wayne, Indiana.*

For more information circle **352** on inquiry card.

High-pressure Hose

New line of "Hi-Duty Pressure Hose and Reusable Couplings" for use in making up hose assemblies for hydraulic and other heavy duty applications includes: single-wire-braid rubber-covered hose, double-wire-braid


5892

rubber-covered hose, and single-wire-braid cotton-covered hose. All conform to both SAE and JIC standards.—*The Imperial Brass Mfg. Co.*, 1200 *W. Harrison St., Chicago 7, Ill.*

For more information circle **353** on inquiry card.

High-pressure Hose

New "No. 1508" high-pressure flexible hose, available in ⅜", ½" and ¾" sizes, will withstand surge pressures

5801

15 to 20% higher than maker's standard high-pressure hoses.—*Aeroquip Corp.*, 300 *S. East Ave., Jackson, Michigan.*

For more information circle **354** on inquiry card.

Tube Fittings with Straight Thread Mounting

New tube fittings for internal straight thread boss mounting are said to solve tapered pipe thread leakage problems in high pressure hydraulics; utilize O-ring sealing; are offered in both "Triple-lok" standard J.I.C. 37° flare type and "Ferulok" flareless type.—*Parker Appliance Co.*, 17325 *Euclid Ave., Cleveland* 12, *Ohio.*

For more information circle **355** on inquiry card.

Insulating Tube Fittings

New "Swagelok" galvanic insulators of "Zytel" polyamide resin offer a new method of eliminating galvanic

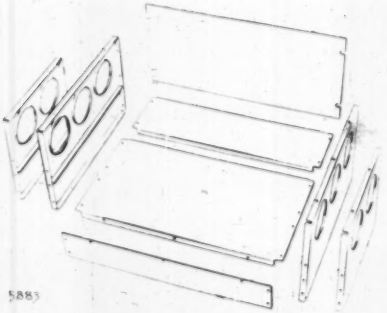
5835

action which results from joining dissimilar metals; will also find many applications at junction boxes, panel boards and bulkheads. Complete line of shapes, 1/16" to 1" tube and pipe sizes.—*Crawford Fitting Co.*, 884 *East* 140*th St., Cleveland* 10, *Ohio.*

For more information circle **356** on inquiry card.

R & D Chassis

New "Vari-Flex" flexible research and development chassis can be used with maker's lines of regulated power


5883

supplies and special-function circuits, or blank as a development chassis; also as a utility breadboard. Back panels can be used between chassis plates for compartment shields or mounting panels. Two standard chassis plates, 4½" and 9", can be interchanged as desired. Available in complete assemblies or as individual components.—*Hamner Electronics Co., Inc., P. O. Box* 531, *Princeton, N. J.*

For more information circle **357** on inquiry card.

NUCLEONICS

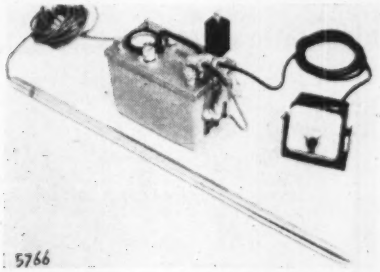
15-tube Geiger Counter

New "Halotron 15" portable 15-tube Geiger counter, said to have "greater sensitivity than any such instrument now on the market," weighs 4¾ lbs, is designed to detect deep hidden uranium ore, and for general survey work. It is powered by two standard "D" flashlight cells and three miniature "B" batteries. It is said to be "the only instrument of its kind that is completely waterproof and shockproof." It carries a one-year guarantee.—*Nuclear Measurements Corp.*, 2460 *N. Arlington Ave., Indianapolis* 18, *Ind.*

For more information circle **353** on inquiry card.

Survey Counter

New "Model SC130GP" portable scintillation counter with hole probe and alarm meter attachments makes



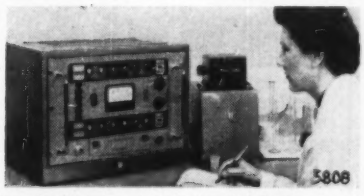
5766

it possible to conduct scintillation counter surveys on foot and by car, and conduct surface and hole exploration with a linear Geiger probe; incorporates all features of earlier models including sodium iodide crystals hermetically sealed independent of phototube.—*Mt. Sopris Instrument Co.*, 1320 *Pearl St., Boulder, Colo.*

For more information circle **359** on inquiry card.

Scaler and Timer

New "EKCO Model N-530A" 6-decade automatic scaler and timer, said to be "the most outstanding and versa-



5808

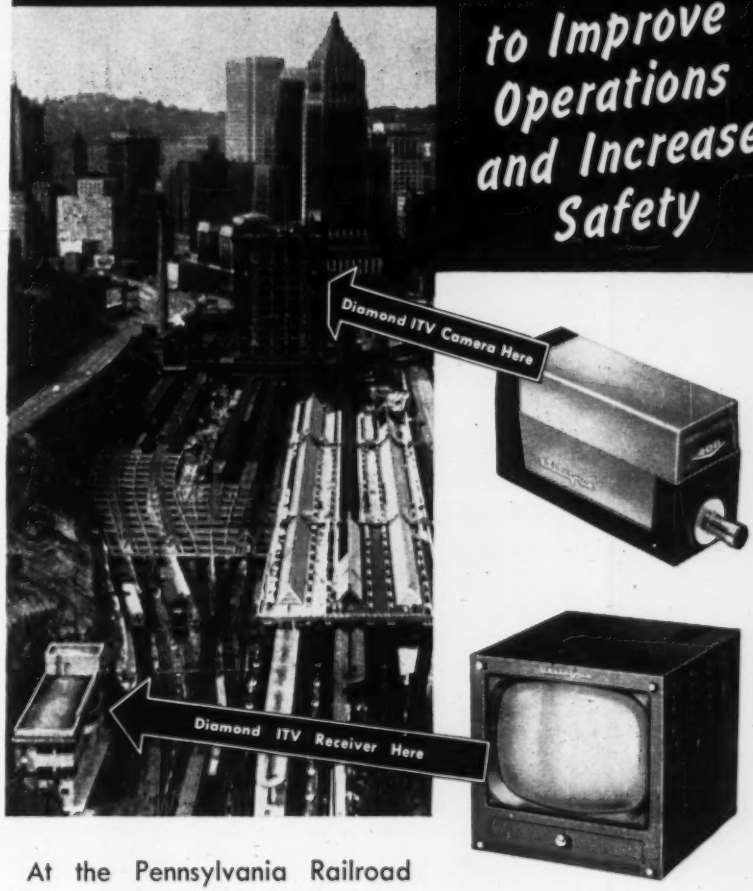
tile instrument of its kind," can be used to time a predetermined count, or to count for a predetermined time, or as a manually-operated scaler. Counting and timing are accomplished through "Dekatron" tube circuits; input resolution time 5 usec, whence "unusually low coincidence loss." Inclusion of a 5-50-v pulse height discriminator in circuitry permits use with G-M, scintillation, flow or proportional counters.—*American Tradair Corp.*, 34-01 *30th St., Long Island City* 6, *N. Y.*

For more information circle **360** on inquiry card.

Scintillation Counter

New "Gamma Gun" is said to be "the first fully-transistorized . . . the only self-contained, hand portable scintillation counter giving 500,000

PENNSYLVANIA RAILROAD
uses DIAMOND
INDUSTRIAL TV
to Improve Operations and Increase Safety



At the Pennsylvania Railroad terminal building in Pittsburgh, Diamond ITV watches the movement of mail cars in and out of the Post Office. The image is transmitted to the train director in a control tower 2000 feet away and on the other side of the terminal.

You, too, probably can use Diamond ITV to substantial advantage. For case histories and suggestions, get in touch with your Graybar Distributor or use the coupon below.

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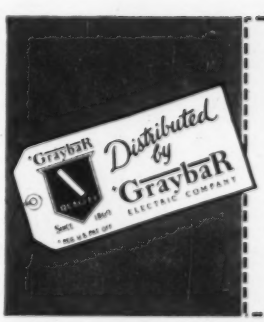

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For more information circle **89** on inquiry card.

SERV-RITE

Insulated Thermocouple Wire Extension Lead Wire

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No matter what your wire or insulation requirements may be, you can depend on Gordon "Serv-Rite" insulated wire for pyrometers—recognized as a standard of highest quality for nearly half a century. All "Serv-Rite" wire is now manufactured in the new, completely modern Gordon plant, employing up-to-date equipment and machinery, supervised and operated by skilled technicians—your guarantee of continued precision quality. In addition to maintaining large stocks of all common types of wire, Gordon will manufacture special insulation, in long or short runs, to suit your individual needs and meet your most rigid specifications.

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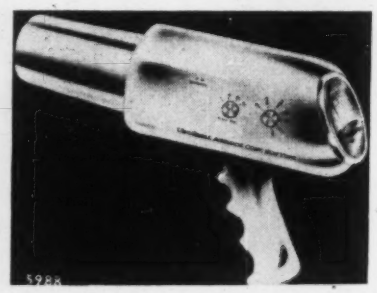
For more information circle **80** on inquiry card.

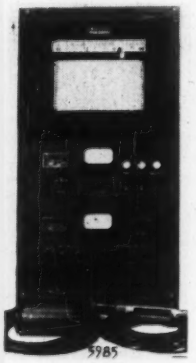
NEW INSTRUMENTS



counts per minute—300 times as sensitive as a single Geiger tube." It has six operating ranges and four time constants; use of transistors in combination with mercury cells "completely eliminates drift."—*Universal Atomics Corp., 19 E. 48th St., New York 17, N. Y.*

For more information circle **361** on inquiry card.

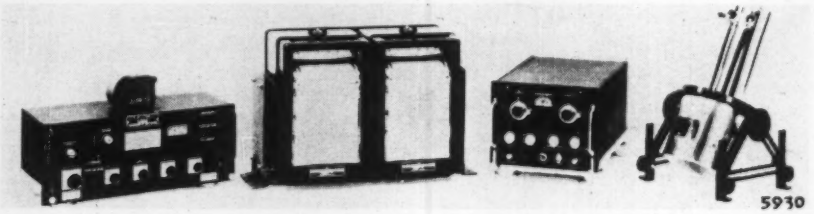
Continuous Area Monitor



New "Model AM-1" can operate unattended for a week or more, continuously indicating and recording radiation. Unique circuits are not only ultrastable but produce direct-reading logarithmic readings. Pickups: for gamma, 50-cu-in ion chamber; for beta, Tracerlab "TGC-2" GM tube; both with 35-ft cables. Ranges: gamma: 0.01/0.1/1/10 mr/hr; beta: 10/100/1000/10,000 cpm. Chart speed 0.5 iph (about 100" per week).—*Trott Electronics Co., 27 Gorham St., Rochester 5, N. Y.*

For more information circle **362** on inquiry card.

Surveying Instrumentation



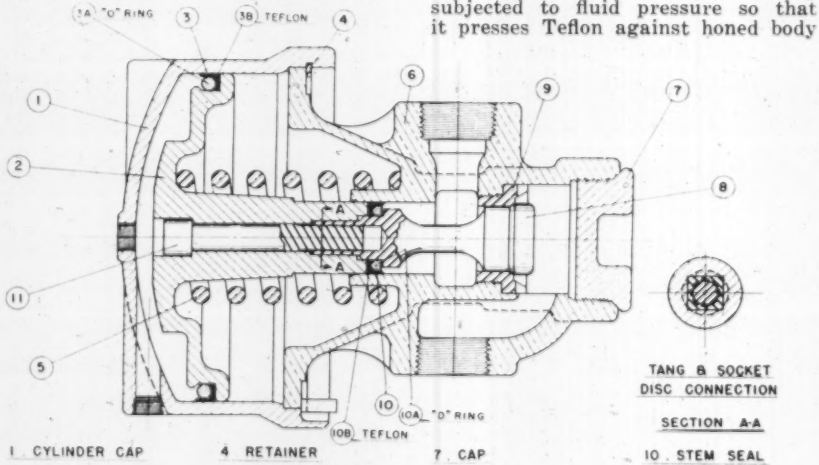
New "Airborne-Carborne Scintillation Counter Model SC188DA" features: dual level discrimination against high- and low-energy radiation for limited spectral selection; range expanding at no sacrifice in sensitivity; dual recorder for synchronous logging of absolute altitude and counting rate; high pulse resolution and linearity.—*Mt. Sopris Instrument Corp., 1320 Pearl St., Boulder, Colo.*

For more information circle **363** on inquiry card.

VALVES

Air-cylinder-operated Control Valves

New "D530 Series" valves are said to represent "a radically different concept in control valve design" and to be remarkable in three principal ways: (1) packing moves with stem which is integral with inner valve; (2) eleven parts as compared to conventional valve's 20 or more; (3) size is much smaller than that of conventional valve. New packing combines sealing ability and low friction of Teflon with springiness of O-rings. A Teflon ring of L cross-section is held in place in carrier by an O-ring subjected to fluid pressure so that it presses Teflon against honed body

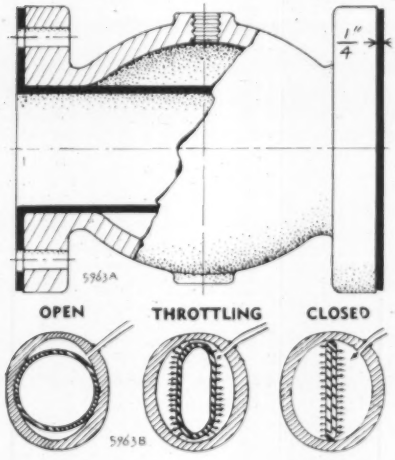


bore to form an effective seal (has been used satisfactorily on pressures as high as 20,000 psi). Packing diameter being larger than seat ring, net unbalance is no greater than that in conventional double-seated semi-balanced valves. Same packing type is used on operating piston, whose effective area is uniform throughout stroke. Cylinder also is honed to minimize friction and effect a perfect seal. Working pressures to 2000 psi and operating temperature to 350°F. Operating cylinder is suitable for air pressures to 100 psig.—*Emmett Machine & Mfg., Inc.*, 445 *E. Turkeyfoot Lake Rd., Akron* 19, *Ohio.*

For more information circle **364** on inquiry card.

Control Valve for Vapor Lines

New "Low Pressure Series R" for acid vapor lines or other low-pressure applications having solids in suspen-

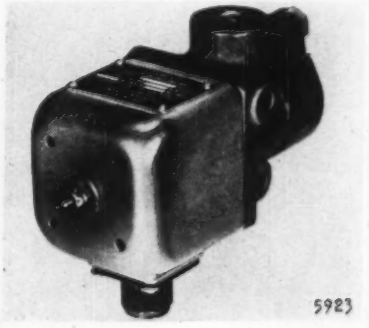


sion can be operated pneumatically or hydraulically. Body is aluminum; sleeve pure gum rubber, butyl or neoprene. Sleeve can be pulled through body to be replaced. Sizes 1" to 4". —*Red Jacket Co., Inc.*, 513 *Bell Ave., Carnegie, Pa.*

For more information circle **365** on inquiry card.

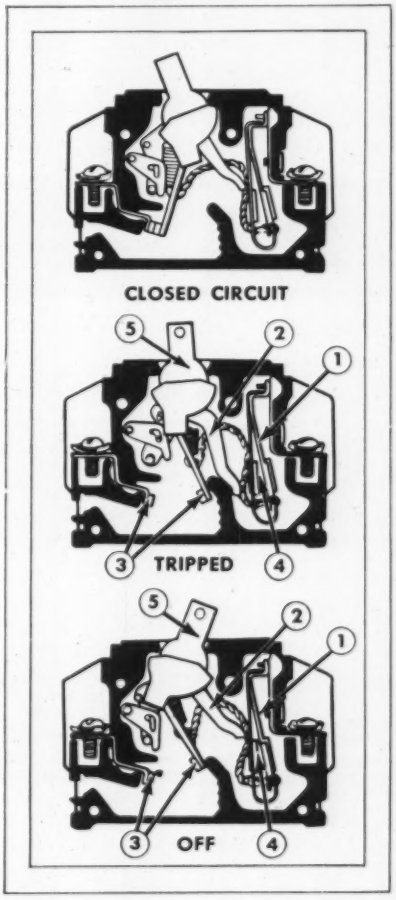
Solenoid-operated Valve

New "Model 21" explosion-proof solenoid-operated hydraulic shut-off valve is immediately available in any variation because all various components that could be required have been manufactured and are in stock. Over-all dimensions 4.67" x 2.03" x



How **CHACE THERMOSTATIC BIMETAL** Actuates the **Westinghouse** AB CIRCUIT BREAKER

Product of Westinghouse Electric Corp., Beaver, Pa.



Westinghouse AB Circuit Breakers are made in a wide range of capacities and types to provide foolproof protection against electrical current faults in residential, commercial or industrial wiring systems. Westinghouse AB Circuit Breakers employ a thermal-magnetic action for *sure* response to gradual or sudden overloads and short circuit faults.

HOW IT WORKS

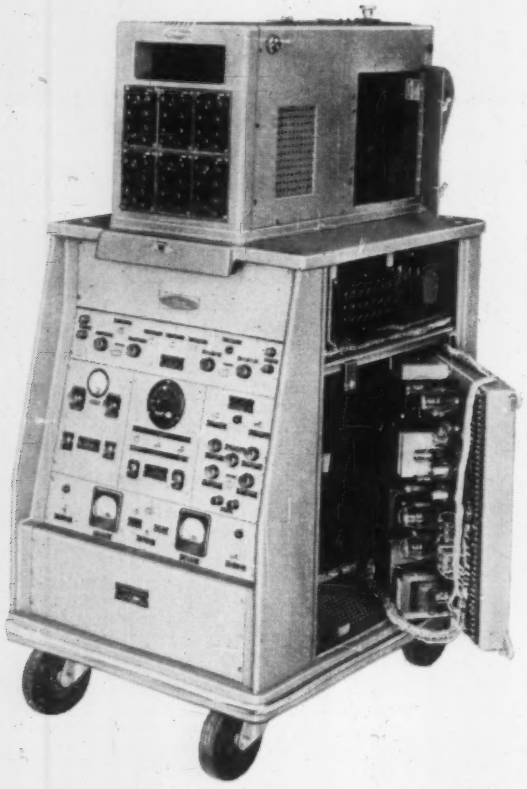
A Chace Thermostatic Bimetal element (1) responds to temporary overloads by deflecting in a direction away from the spring loaded latching arm (2) causing the contact rocker to break the circuit at contacts (3) in response to the same spring tension. Under conditions of sudden, high overload, the magnetic trip element (4) trips the latching arm in the same manner. A simple flip of the reset handle (5) again closes the circuit after the fault has been cleared from the line.

Chace Thermostatic Bimetal is available in 29 different types, in coil, strip, or in complete elements fabricated to your specifications. To aid the product designer of thermally responsive devices, we offer a free 36-page booklet, "Successful Applications of Chace Thermostatic Bimetal." *Write today for your copy.*

IT BENDS WITH THE HEAT

W. M. CHACE CO.
Thermostatic Bimetal
1609 BEARD AVE., DETROIT 9, MICH.

For more information circle **42** on inquiry card.



Multi-channel Recording D-C to 200 kc

Hathaway New SC-16B

The SC-16B is a complete oscillograph which records up to 12 signals on a single chart. It produces sharp, well defined records even at the highest frequencies. The SC-16B is useful in research programs requiring multi-channel, high frequency recording of pressure, strain, vibration, and acceleration.

SPECIFICATIONS

Number of Channels: Up to 12 **Chart Speed:** 1.6 to 6000 inches per second **Chart Size:** 6 inches x 100 or 200 feet; 6 inches x 15 inches; 6 inches x 10 feet; 35 mm. x 400 or 1000 feet **Frequency Response:** D-C to 200 kilocycles **Writing Rate:** 5,000,000 inches per second **Chart Speed Change:** 16 speed quick-change transmission **Voltage Input Level:** 1.5 volts r.m.s. per inch on tube screen; 1.5 millivolts r.m.s. per inch on tube screen with type ASC-10 D-C Amplifier **Timing Lines:** Precision tuning fork controlled at 1/100 or 1/1000 second intervals **Synchronization:** Transient can be initiated from oscillograph, or transient can initiate oscillograph **Record Length Control:** For continuously-moving-chart recording, 0.75 to 15 seconds; for drum-type-chart recording, 5 milliseconds to 1 second.

Write for bulletin 2-G1-H

Hathaway
INSTRUMENT COMPANY • DIVISION OF
Hamilton
WATCH COMPANY

1315 SOUTH CLARKSON • DENVER, COLORADO

For more information circle **91** on inquiry card.

3.5". Available in tube sizes from ¼" ½"; operating range 0 to 5000 psi; temperature range −65 to 275°F; flow rates 0 to 10 gpm.—*Mar Vista Eng'g Co., 5420 W. 104th St., Los Angeles 45, Calif.*

For more information circle **366** on inquiry card.

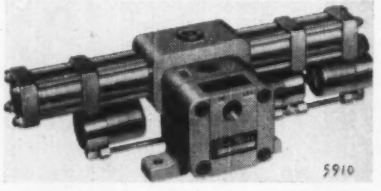
Diaphragm Control Valve

New "Bantam Bellows Sealed Diaphragm Control Valve" provides positive leakproof control of hazardous process flows. Photo shows "Assembly #2038" with special flange facing to receive ½" 150-lb ASA raised face flange, action air-to-close, Teflon seating, with extra Teflon packing above bellows. Bellows rating 500 psig from 70° to 700° F. Screwed or flanged ends to user's specs.—*George W. Dahl Co., Inc., 430 High St., Bristol, R. I.*

For more information circle **367** on inquiry card.

Four-way Control Valve

New "Model PON Power Operated Valve" features power operation to forward, reverse and neutral; is a

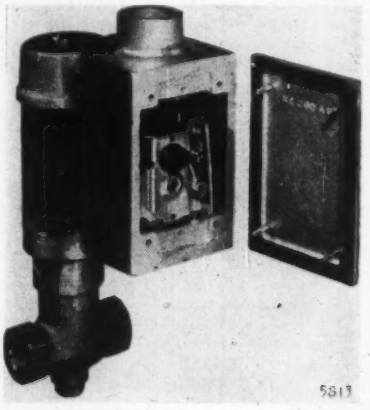


4-way disc valve for air, gas, oil or water service, controlled by maker's 3-position power attachment operated by air or gas. Body and disc are lapped to optical accuracy for perfect seal.—*Ledeen Mfg. Co., 1600 So. San Pedro St., Los Angeles 15, Calif*

For more information circle **368** on inquiry card.

Timer Valves

New time-controlled solenoid valves offer various time cycles: repeat cycle continuously intermittent during op-



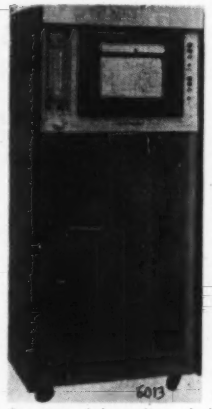
eration; on and off at preselected times for daily repeat cycle operation; opening valve at any time with automatic shut-off after selected opened time. Available in many sizes for gas, water and air; 110 or 230 vac, 60 cps. —*Automatic Controls Corp.*, 2390 *Winewood, Ann Arbor, Mich.*

For more information circle **369** on inquiry card.

MISCELLANEOUS

Oxidant Recorder

New 'Oxidant Recorder," developed for municipal air pollution studies, has other important uses, such as environmental testing of products affected by air pollution. It measures and records oxidant concentrations as low as 2 parts per hundred million. Its strip-chart recorder has an automatic zero reading once every 24 hours.—*Beckman Instruments, Inc., Fullerton, Calif.*



For more informaiton circle **370** on inquiry card.

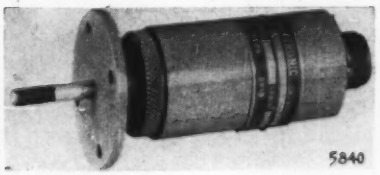
Armored Purge Meter

New "Figure 245 Armored Purge Meter," first of its kind, featuring rugged all-metal construction and 1500-psi ASA pressure rating combined with low cost, uses a magnet and follower to indicate flow rate. Unique feature is easy means of restoring operation should magnet be lost owing to a violent surge in line. If this happens, follower will drop below zero line on scale. To restore magnetic bond, operator merely closes head valve momentarily. Two stock sizes: (1) 25 gph water or 103 scfh free air and (2) 80 gph water or 330 scfh free air equivalent. Not recommended for gas service below 60 psig. Temperature rating is to 400°F; length 7½"; connection size ½" NPT (vertical). Scale graduation 0-100% in 10% increments.—*Fischer & Porter Co., Hatboro 35, Penna.*

For more information circle **371** on inquiry card.

Displacement Pickup

New "Model 100 Universal Displacement Transmitter" (differential-transformer type) transmits motions from 0.000001" to 0.125". Micrometer zero adjustment allows mechanical



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for heavy duty industrial applications

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DUST TIGHT
OMNIDIRECTIONAL

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Perfect oil-tightness is effected by retained oil-proof gaskets and the gasketed glass lens assembly.

These units have many heavy-duty features: *One-piece solid brass bushing, solid brass lens holder, high impact phenolic insulation, rugged binding screw terminals.*

They install easily in a single 1" or 1 3/16" panel mounting hole. Other units available for 1 1/16" mounting hole. *A choice of 3 lens styles, 7 lens colors,* and other optional features provide adaptability. If you have an unusual problem, consult our engineering department.

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For more information circle **43** on inquiry card.

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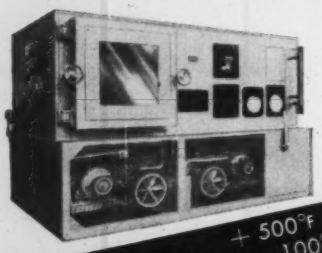
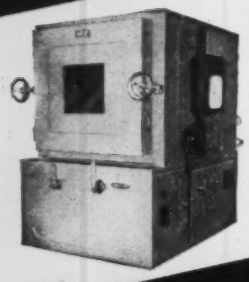
ENVIRONMENTAL TEST EQUIPMENT

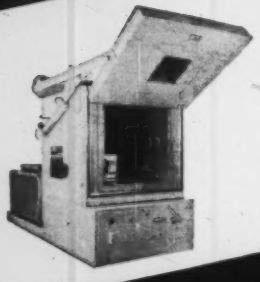
in any combination



TEMPERATURES: + 500°F to −100°F and lower



ALTITUDE: to 100,000 feet and higher



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For more information circle **83** on inquiry card.

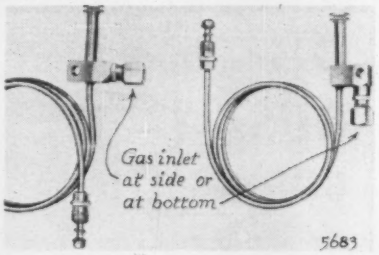
NEW INSTRUMENTS

and electrical zero to be adjusted with extreme precision after installation. Sensitivity 5 mv/mil with 6.3-v. 60-cps excitation; output impedance 200 ohms.—*Daytronic Corp., 216 South Main St., Dayton 2, Ohio.*

For more information circle **372** on inquiry card.

Pilot-burner and TC

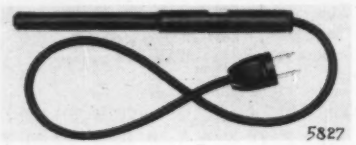
New "Mini-Pilot 200," miniature combination pilot burner and thermocouple, is for use on larger gas appliances. Nominal BTU input is 200, compared with 100 for original "Mini-Pilot." Built-in thermocouple safety shut-off is said to be "capable of generating a higher voltage than other similar types."—*Robertshaw-Fulton Controls Co., Long Beach, Calif.*



For more information circle **373** on inquiry card.

Magnetic Erasing Pencil

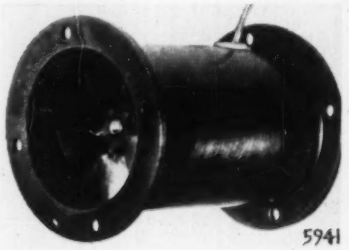
New "Magnetic Erasing Pencil type 8905," for erasing small areas (a syllable or part of a word), uses 10 watts 115 vac 60 cps, comes complete with press-to-operate switch and 6 ft of cord.—*Cinema Engg. Co., Div., Aerovox Corp., Burbank, Calif.*



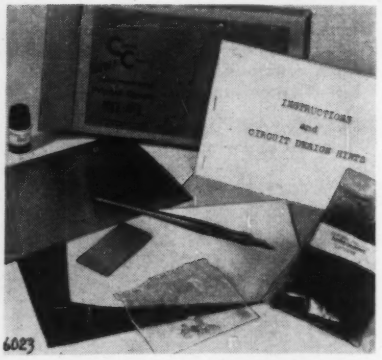
For more information circle **374** on inquiry card.

2″ Axial Blower

New "Type AXB2249" 2" axial blower puts out 25 to 30 cfm at zero static pressure yet weighs 8 oz. and



Graphic-circuit Kit



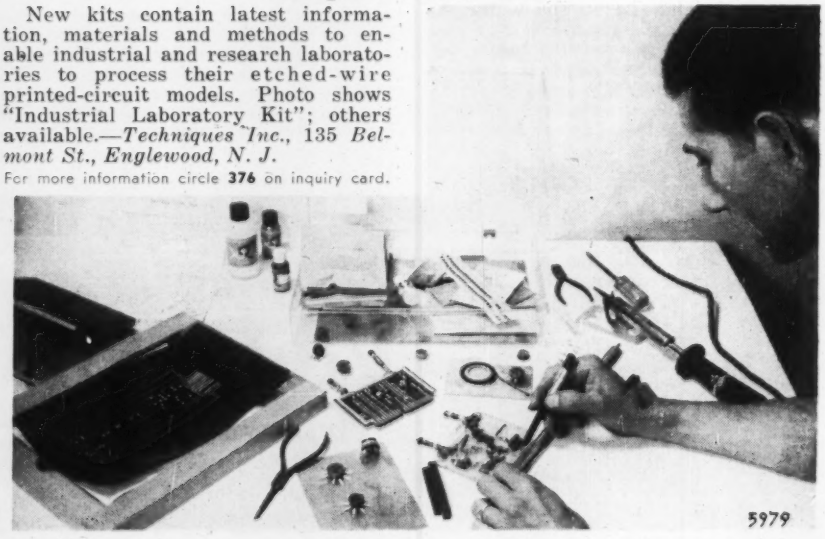
New do-it-yourself etched- or printed-circuit kit enables engineer to evaluate his designs before production; effects savings in time and money by obviating need for outside sources of supply; was designed and is produced by engineers who use identical kits in their own work; includes an 8½ x 5″ sheet of copper-clad laminate and all other materials required to make etched or printed circuits, also instruction booklet; can be used to make two average size miniaturization circuits or one standard size circuit. Replacement parts are also listed.—*Control Circuits, Inc., 24 Broad St., Middletown, Conn.*

For more information circle **375** on inquiry card.

Graphic-circuit Kits

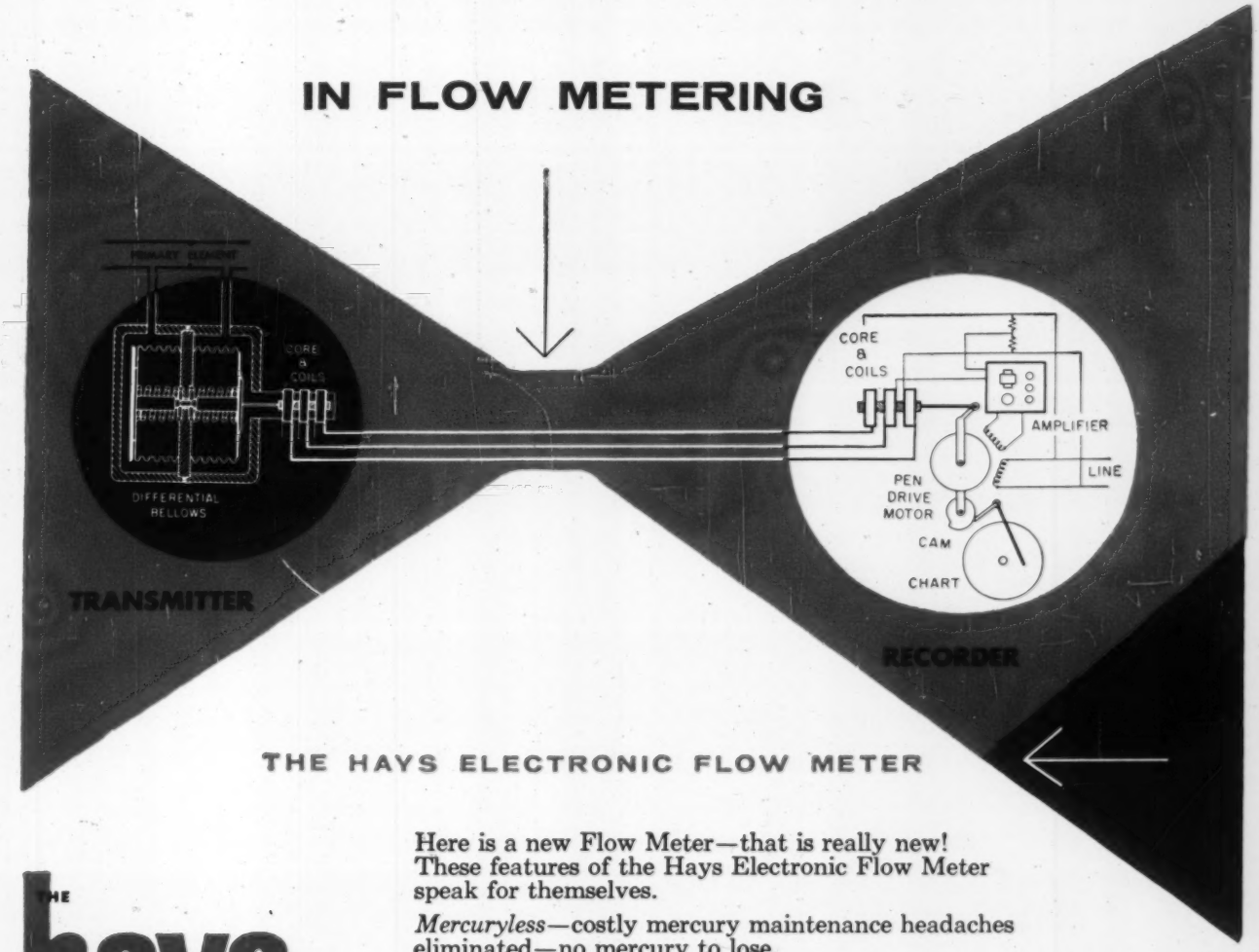
New kits contain latest information, materials and methods to enable industrial and research laboratories to process their etched-wire printed-circuit models. Photo shows "Industrial Laboratory Kit"; others available.—*Techniques Inc., 135 Belmont St., Englewood, N. J.*

For more information circle **376** on inquiry card.



new dimensions

IN FLOW METERING



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THE **hays** CORPORATION

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Here is a new Flow Meter—that is really new! These features of the Hays Electronic Flow Meter speak for themselves.

Mercuryless—costly mercury maintenance headaches eliminated—no mercury to lose.

Rupture-proof Bellows—provide positive protection against over-range.

Continuous integration—motor-driven continuous mechanical integrator is extremely accurate even on rapid load changes.

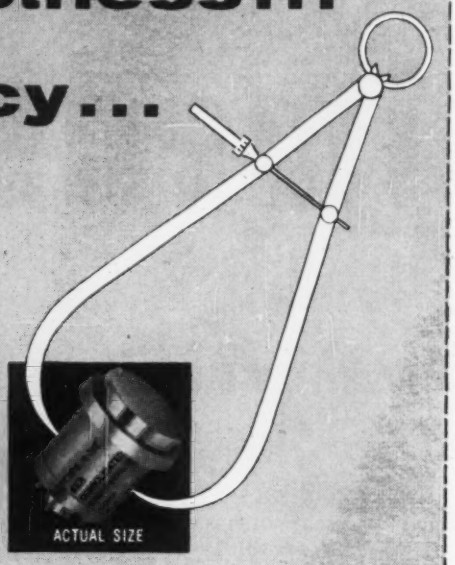
Electronic operation—requires only 4 seconds for full scale pen travel with accuracy of ¼% of full scale differential.

Other features include null-balance transmission, powerful motor, easy readability, accuracy unaffected by normal temperature changes. Explosion proof transmitters and wide range meters also available.

For complete information, write for Bulletin 54-1074-222.

For more information circle **84** on inquiry card.

compactness... accuracy...



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What surprises most engineers the first time they see one of CEC's 4-300 Pressure Pickups is its small size. But when they learn of the performance, surprise often turns to amazement. With the 4-300's, there's no compromise on either compactness or accuracy . . . you get *both* in a single unit, with ruggedness that provides laboratory accuracy under the most adverse conditions of use.

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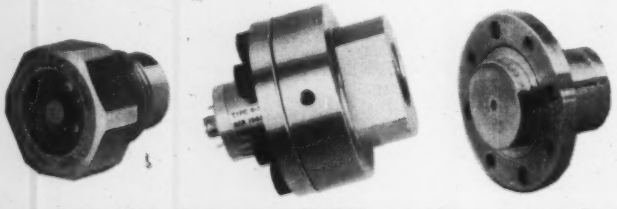

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NEW INSTRUMENTS

measures 3.375" L x 2.87" OD. Operating temperature range —55°C to 71°C. Other military aircraft environmental requirements are also met.—*John Oster Mfg. Co., Avionic Div., 1 Main St., Racine, Wis.*

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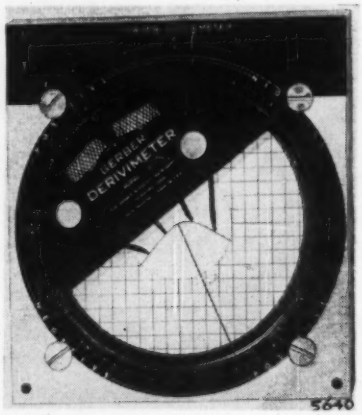
Slope Reader

New "Derivimeter," designed to obtain derivatives of plotted curves, yields the normal as well as the slope



directly, without computation, whence "an enormous saving in time even when exact equation is known." It is useful not only in data reduction but in laying out cams, in compiling velocity and acceleration data from displacement curves, etc.—*The Gerber Scientific Instrument Co., 162 State St., Hartford, Conn.*

For more information circle **373** on inquiry card.

Combination Timer on Oil-well-pump Starter

New combination timer, obviating need for separate sequence timer, undervoltage relay and program timer, has been incorporated into maker's oil-well pumping starters equipped for automatic sequence restarting; can be set for pumping periods as short as 15 min. After a power failure, pumping motor will start only if momentary contact is closed and program time setting calls for pumping. —*General Purpose Control Dep't., G-E, Schenectady 5, N. Y.*

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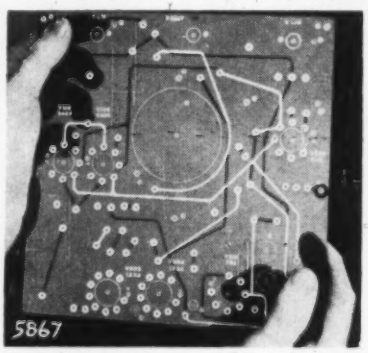
Translucent Plastic

New "XXXP-36" laminated plastic's translucency is said to allow, "for the first time, a visual check on the accu-



racy of printed circuit register." New material also helps make printed circuits accurate and provides a million megohms insulation resistance. Since it punches cold in thicknesses up to and including 1/16", no heat cycle is required; thus base laminate is not subject to dimensional change as in grades which must be heated before punching.—*The Formica Co., Cincinnati 32, Ohio.*

For more information circle **380** on inquiry card.

Inspection Mirror

New "G-C Shockproof Inspection Mirror," being all-plastic, is completely safe for use around high voltage

areas of a TV or other chassis.—*General Cement Mfg. Co., 400 South Wyman Street, Rockford, Illinois.*

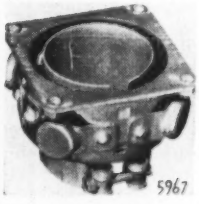
For more information circle **381** on inquiry card.

Teletype Tape Storage Feeding System

New automatic teletype tape storage system for railroad yards stores switching information for a complete train, so that all cars in a train can be classified and routed to desired tracks in the yard without necessity for operator to push a button. Switches (required to route each car to its designated track) position automatically as the car advances.—*Union Switch Signal, Pittsburgh 18, Pa.*

For more information circle **382** on inquiry card.

Shock Mounts for Electron-tube Protection



New "Model K271" insures against shattered tubes and waveform distortion during operations. Integral metal sleeve serves as a brace and support for the tube, which can be adjusted with a screw clamp. "Met-L-Flex" spring-enclosed stainless-steel cushions attenuate shock and vibration between sleeve and outer support.—*Robinson Aviation, Inc., Teterboro, New Jersey.*

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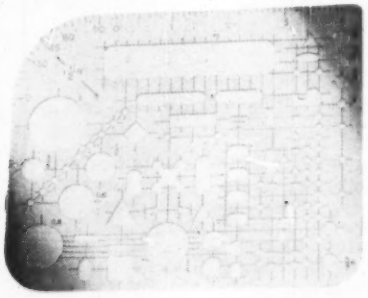
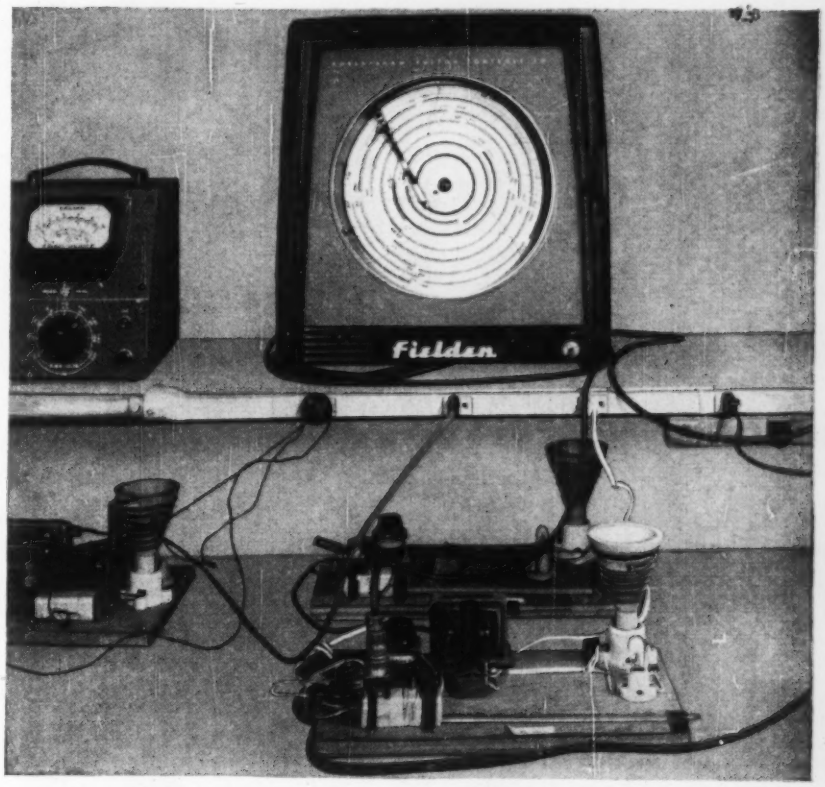
Drafting Templates

New additions to maker's assortment of drafting templates are said to make this line "the most complete



Fielden Variable Zero Recorder Assures Accurate Readings over Wide Range



Although its thermostats are tested at many different temperature settings, G-V Controls, Inc. of East Orange, N.J., needs only one instrument to accurately record life-tests of thermostats over the entire range of test conditions.

The answer is a Fielden Resistance Temperature Recorder with a variable zero suppression. A twist of a dial, and this recorder selects any 20° span within a 0-250° F range. As a result, the record is always accurately readable to better than ±0.2° F.

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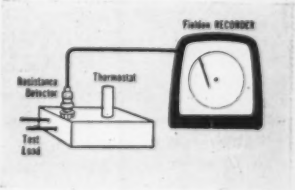

Robertshaw-Fulton
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FIELDEN INSTRUMENT DIVISION
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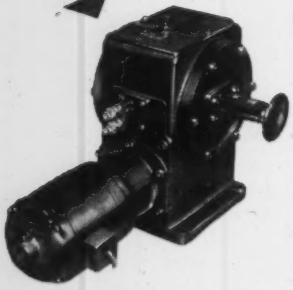
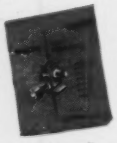
A portion of the 200 acre scale model of the Mississippi Basin, shows one of the Askania Controls used in this flood control study.

Huge 200 acre experiment needs PRECISE CONTROL!



The Askania Unit Regulator, a completely self-contained automatic control. This versatile unit, one of an extensive line, finds its widest use in applications where measured signals are low level and power requirements at the point of control are moderate.



The Corps of Engineers, U. S. Army uses a 200 acre scale model of the Mississippi Basin in flood control studies that may eventually solve that area's flood control problem. In the studies, six standard Askania Controllers were used to assist in precisely simulating the behavior of one of the world's mightiest river systems.

While flood control may not be your problem, precise, sensitive, and powerful Askania controls may be the solution to your control problems. These units are currently solving problems in the metal, glass, plastic, rubber, textile and paper processing industries. If you have control problems that are boosting your costs or lowering your product quality, investigate these Askania Controllers.

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ASKANIA REGULATOR COMPANY
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For more information circle **11** on inquiry card.

available." Line includes drafting templates for electrical and electronic symbols, 3/16" and 5/16" fluid fittings, ¼" and ⅜" fluid fittings, ½" fluid fittings, ¾" fluid fittings, full-size nuts and bolts, half-size nuts and bolts, small ellipses, large ellipses, lettering, tooling, circles and sheet thickness. They are made of amber-coated vinyl plastic, 0.025" thick.—*E. F. Twomey Co., Inc., 728 W. 10th Pl., Los Angeles, Calif.*

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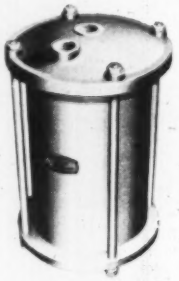
Air Filters



New "Series 350 Super Clean" air filters are designed to remove all traces of oil and oil vapors, all solid particles over three microns in size, odors and fumes, and moisture. Units will absorb large quantities of contaminants before filter need be changed. Available models for ¼", ⅜", ½", ¾" and 1" lines.—*Wilkerson Corp., 1601 W. Girard Ave., Englewood, Colo.*

For more information circle **385** on inquiry card.

Conductivity Bridge

New "RB-188-1" version of maker's "Solu Bridge" is a highly-sensitive easy-to-use electrolytic conductivity instrument especially designed for detecting salt water intrusions or presence of slugs of pollution in streams and wells. It comprises a lightweight, battery-operated, portable ac bridge and special weighted conductivity cell with extra-long extension cable. It covers a wide range of conductance: 40 to 40,000 micromhos; has automatic temperature compensation; can be operated by non-technical personnel under practically all conditions.—*Industrial Instruments, Inc., 89 Commerce Rd., Cedar Grove, N. J.*

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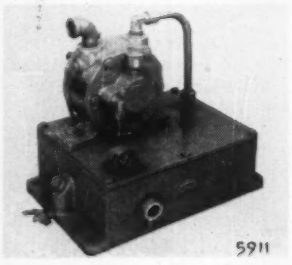
Air Pumps

New line of straight-wing rotary air pumps feature a reduction of 33% in over-all height and an increase in



vacuum to as low as 0.4 mm. mercury absolute. Capacities from 2.4 to 40 cfm. When used for pressure, new pumps provide range of 15 to 20 psig.—*Leiman Bros., Inc., 102 Christie St., Newark 5, N. J.*

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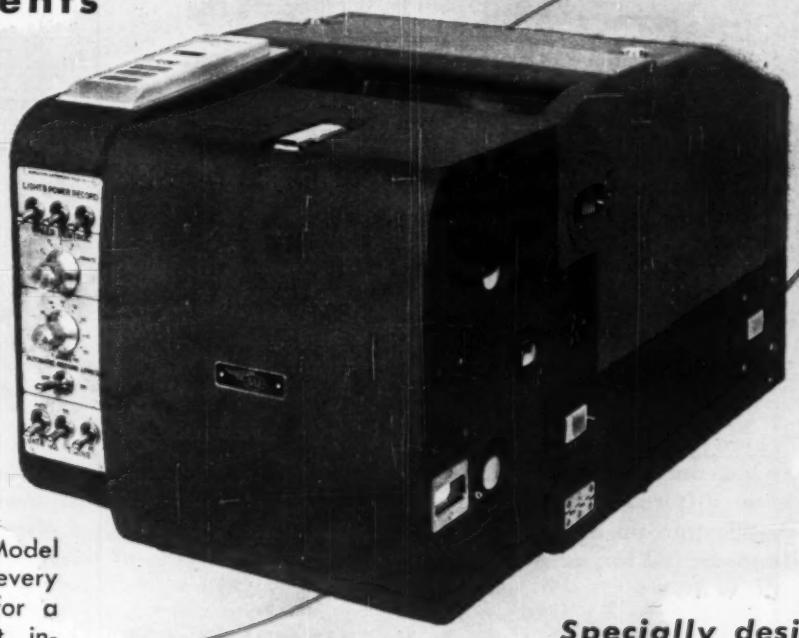
A uniquely NEW Oscillograph from Midwestern Instruments



Midwestern's New Model 590 incorporates every feature necessary for a successful flight-test instrument.

*Specially designed for remote control**

**If desired the instrument can be supplied with no controls on it. All control then originates at a remote location.*

Here's another great development in Midwestern's series of famous flight-test instruments. It is based on extensive experience applying other Midwestern oscillographs to many combinations of environmental conditions. One of the many features is a remotely-controlled jump-speed system. Speed may be changed at any time by simply positioning a rotary switch to the required setting. 20 recording speeds are possible with this electrically-actuated system and change gears within the oscillograph. Lamp intensities are automatically adjusted to a previously-set value for recording at the new speed. The single aluminum alloy casting is ribbed for the strength and rigidity needed under high acceleration conditions.

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Fundamentals of

PRESSURE CONTROL

Where should I use a self-operated regulator, and where should I use an instrument-type pressure controller? This question requires review of the basic differences between pressure regulators and pressure controllers. Application on a fractionating column highlights this basic discussion of fundamental importance, and illustrates various types of possible control.

A. M. THACKARA

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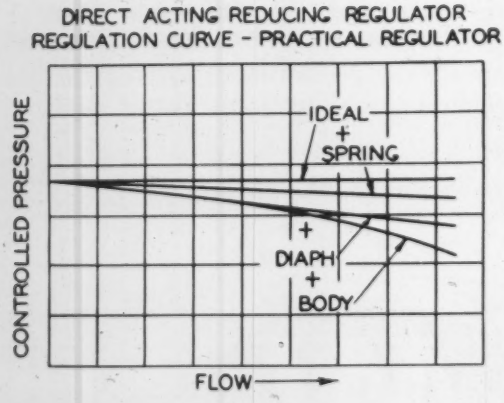


Fig. 1. Characteristic curve of a pressure regulator is a plot of controlled pressure vs flow. Ideal would be straight, horizontal line. In self-operated pressure regulator, the spring, diaphragm, and body all contribute to deviation from the ideal.

PRESSURE CONTROL can be effected with either self-operated instruments, which are commonly called *regulators*, or instrument-type devices of greater complexity, which we shall call *controllers*. In order to select the optimum type for a given application, it is necessary to know the advantages and limitations of each type.

Direct-Operated Pressure Regulators

Regulators can be classified as weight-loaded, pressure-loaded and spring-loaded. The diaphragm which measures the pressure is also required to open and close the valve, with the result that the characteristic curve of each regulator is fixed. (The characteristic curve of a pressure regulator is one in which flow is plotted against controlled pressure.)

The bottom curve in Fig. 1 is the characteristic curve of a spring-loaded reducing regulator. The other curves show the relative effects of the spring, the diaphragm, and the body on the control action. Note that the ideal curve would be a horizontal line, indicating constant pressure at all flows. The spring, diaphragm, and body cause deviations from the ideal, because of the following reasons.

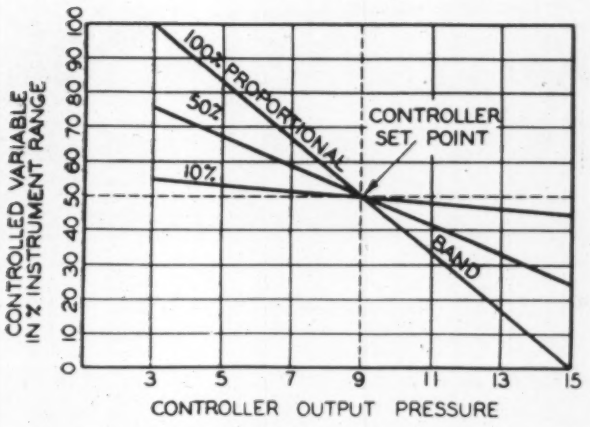


Fig. 2. In instrument-type pressure controllers, the sensitivity (proportional band) can be adjusted because separate measuring elements and final control mechanisms are used. Decreasing the proportional band increases sensitivity.

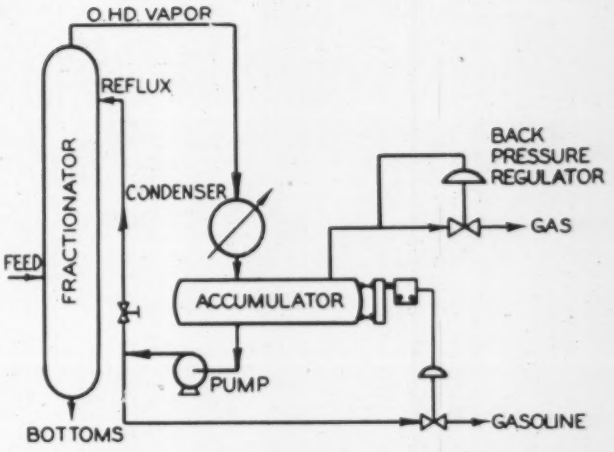


Fig. 3. Simple back-pressure regulator in vapor line from accumulator. Basic disadvantage is that tower overhead vapor pressure may not be controlled to desired accuracy.

Effect of Spring: An increase in flow requires a movement of the plug, which in turn decompresses the spring. As the spring is decompressed, it exerts less force against the diaphragm, and less pressure is required on the other side of the diaphragm to maintain equilibrium. The spring, therefore, has the effect of lowering the controlled pressure as the flow increases.

Effect of Diaphragm: The effect of the diaphragm on the characteristic curve results from the increase of its effective area as the plug is lifted from the seat. Consequently, lower pressure is required to maintain equilibrium with the spring as the flow increases.

Effect of Body: The body effect is simply the result of the body restriction absorbing more pressure drop as the flow increases, thereby lowering the controlled pressure.

The advantages of direct-operated regulators include (1) low cost, (2) high dependability, and (3) low maintenance. Another important advantage is the fact that they are close-coupled with the process so that the movement of the plug follows the variations in control pressure rapidly. In hydraulic service, the response is almost instantaneous, particularly if the connection between the control pressure tap and the diaphragm is short or made internally through the body.

Pressure- and weight-loaded regulators, by avoiding the spring effect, can control the pressure closely, but they are limited to fairly low pressures. By far the vast majority of pressure regulators in use are spring-loaded because (1) they can be used at higher pressures and (2) the pressure setting is made more easily. The spring, however, greatly increases the pressure drop with increased flow so that few spring-loaded regulators can control pressure within 5% of the maximum pressure range. Exact calculation of the pressure drop of a spring-loaded pressure regulator requires knowledge of the spring characteristics (including the spring rate), the effective area of the diaphragm and its change, and the body effect. Since this would have to be calculated for every size of regulator, for every range and for every condition of inlet pressure and pressure drop, it is customary to give a flat percentage figure, such as 10%, whenever the accuracy of control is requested. This figure of 10% is based on the maximum pressure setting, not on the actual pressure being controlled.

Instead of regular January meeting: the Annual SCMA Instrument Short Course will be held at Los Angeles Harbor Junior College, Wilmington, Calif., January 26 and 27. Featured speaker will be Dr. Arnold O. Beckman of Beckman Instruments. Subject is "Better Process Control Through Use of Analytical Instruments and Computers."

Instrument-Type Pressure Controllers

The main difference between direct-operated pressure regulators and instrument-type pressure controllers is that in regulators the measuring element (the diaphragm) is also required to move the plug, whereas in pressure controllers the measuring element actuates a pneumatic control mechanism which produces an air pressure signal proportional to the measured pressure. With a pressure controller, only a small change in the controlled pressure is required to vary the output pressure to the control valve. Also, the change in the controlled pressure required to actuate the control valve can be varied. This characteristic provides for the adjustment of the proportional band, as illustrated in Fig. 2. As the controller output is directly proportional to the control valve lift, varying the proportional band changes the characteristic curve of the controlled pressure with respect to flow. From a control standpoint, this is a significant advantage of the instrument-type controller.

The main advantages of instrument-type pressure controllers over regulators are: (1) greater sensitivity, (2) adjustable proportional band, (3) ease of adjustment, (4) flexibility (i.e., reversibility, remote location, etc.), (5) wider spread of pressure settings within a given range, (6) wider selection of pressure ranges, (7) can be used on higher pressures and pressure drops, (8) wider flow range, (9) can be used where flow conditions require large body sizes, and (10) control valves have standard pressure range.

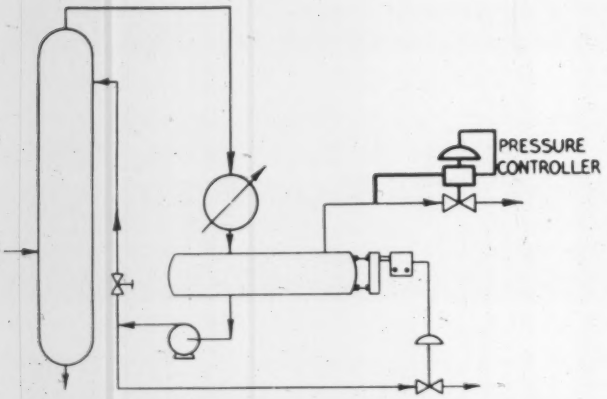


Fig. 4. Addition of a pressure pilot and diaphragm control valve will control the pressure in the vapor line from the accumulator more accurately, but column overhead pressure can vary even though the gas line from the accumulator is controlled.

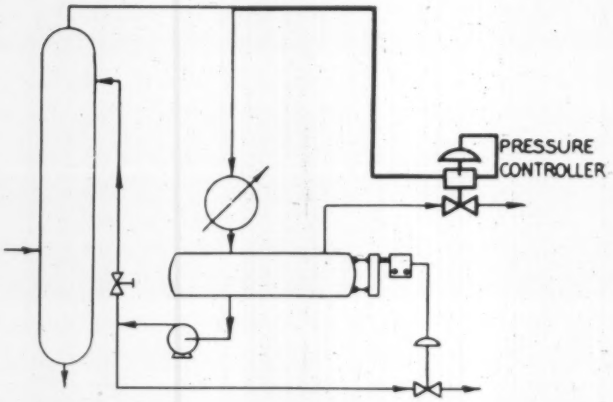


Fig. 5. Overhead vapor pressure can be controlled by controlling back-pressure from the accumulator, with the pressure tap in the overhead vapor line. This introduces time lags which necessitate a widening of the proportional band, which in turn requires reset action to compensate for the resultant offset. Disadvantage of this system is difficulty of adjusting set point on field-mounted controller.

Examples of Pressure Control

Back-pressure control of a fractionating column in which some overhead vapors are not condensed illustrates various control applications. The overhead vapors from the fractionator (Fig. 3) pass through a condenser where they are cooled, and then go into an accumulator where the left-over vapors are separated from the condensate. The liquid products are pumped out of the accumulator, a part going back to the fractionator as reflux, and the remainder being pumped to the next stage of the refining process.

Fig. 3 shows a back-pressure regulator installed in the vapor line from the accumulator. The regulator could be installed directly in the overhead vapor line, but there are three reasons for not doing this:

1. The added pressure drop required for the control valve would reduce the suction pressure and necessitate a larger pump to maintain the same flow.
2. The added pressure drop in the overhead vapor line would increase the required condenser size.
3. The regulator valve, having to pass the total overhead vapor, would have to be larger than the valve installed as shown.

The limitations of this installation (as in Fig. 3) are (1) the regulator does not control the pressure in the column itself, and (2) the regulator may not control closely enough.

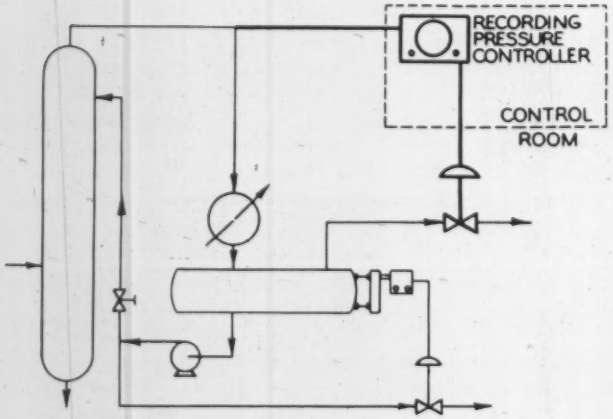


Fig. 6. Locating controller in remote control room solves problem of adjusting controller. Disadvantages now are (1) hazard of running piping from process to control room, and (2) time lags due to long line between tower and controller (which may be filled with compressible vapor) and line between controller and valve.

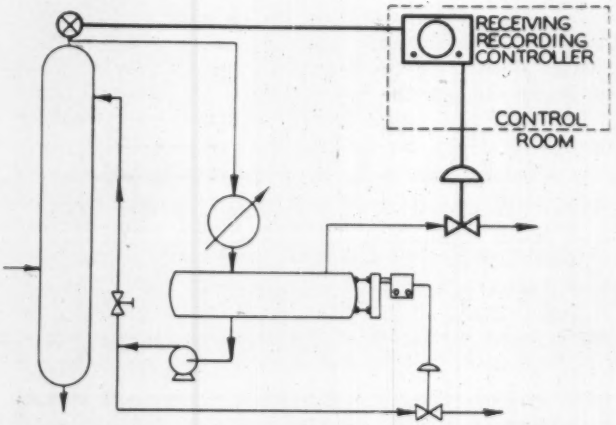


Fig. 7. Use of a transmitter in the overhead vapor line (which develops a pneumatic signal proportional to pressure) overcomes safety hazard of Fig. 6—but time lag due to line between tower and controllers, and line between controller and valve, remain.

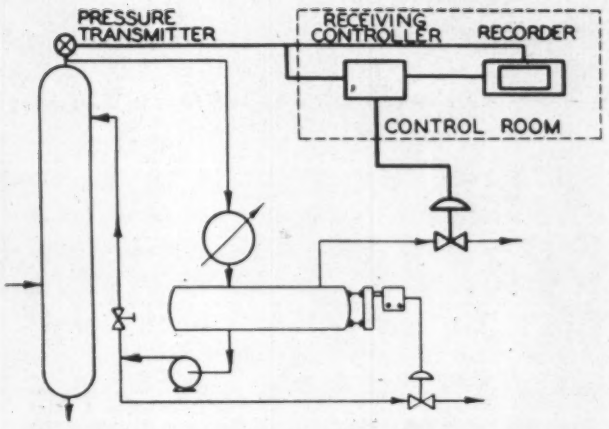


Fig. 8. Time lag between tower and controller can be reduced by using force-balance controller, which has faster response than the deflection-type controller of the systems shown in Figs. 6 and 7.

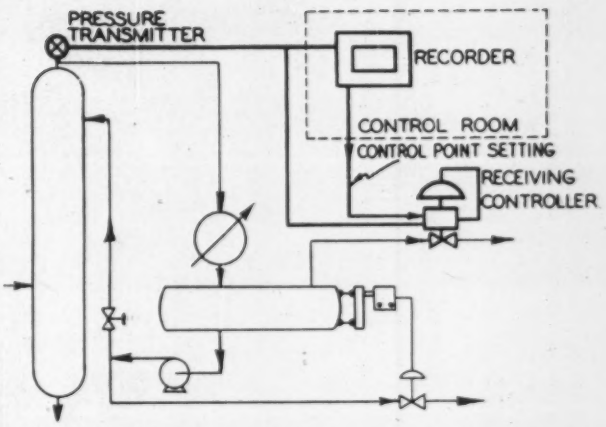


Fig. 9. Final solution uses field mounting of controller on the control valve, reducing lag between controller and valve. Line between controller and recorder provides for setting of control point from control room.

In Fig. 4, a pressure pilot and diaphragm control valve have been substituted for the back-pressure regulator. The pressure tap is made in the gas line from the accumulator. The controller gives fairly close control, but still does not control the pressure in the fractionator directly. Variations in the flow of overhead vapor will result in pressure fluctuations in the fractionator, even though the pressure in the gas line from the accumulator is controlled.

This problem is overcome by having the pressure tap in the overhead vapor line, as in Fig. 5. Unfortunately, this can increase the lag between the point of pressure measurement and the control valve, with the result that the proportional band of the pressure pilot must be widened to obtain stable control. Wider bands result in wider pressure variations when the flow changes. This problem can be overcome by adding reset action to the pressure controller. Variations in flow will cause variations in controlled pressure, but these will be of short duration and will be corrected by reset action.

The use of a valve-mounted pressure controller with proportional plus reset control action would be satisfactory were it not for the difficulty in making the adjustments on the controller, such as changing the set-point. Fig. 6 shows the pressure controller located in a control room some distance away from the control valve. The controller also records the controlled pressure. The main objection to this installation is the hazard of running piping from the process to the control room. Furthermore, since the overhead vapors are compressible, the time lag between the occurrence of the pressure fluctuations in the overhead vapor line and the correcting action of the control valve has been increased, requiring an even wider proportional band. Variations in the flow will result in pressure fluctuation of longer duration than in the case of the valve-mounted controller. If the control line is filled with condensate, the lag between vapor line and controller is greatly reduced and the response improved, but the lag between controller and valve remains.

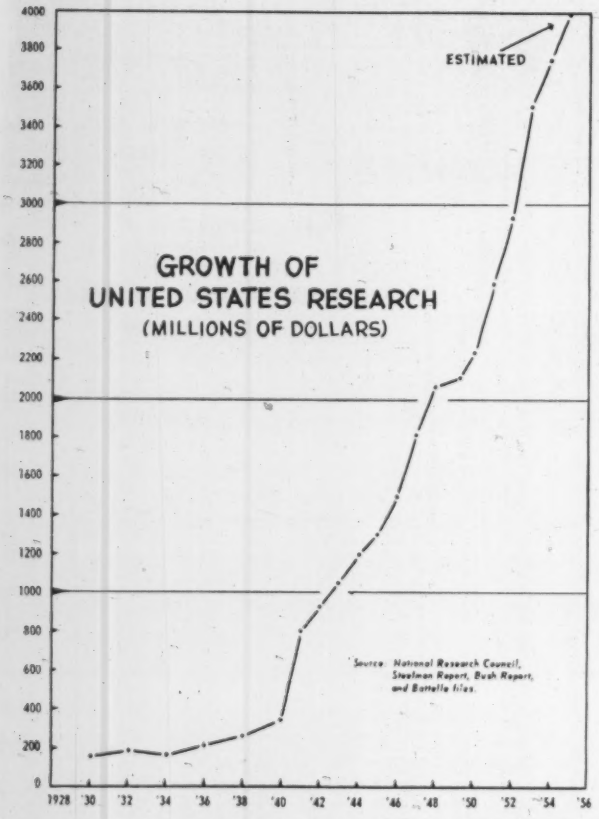
In Fig. 7, a pressure transmitter has been installed in the overhead vapor line to transmit an air signal to a receiving recording controller. The installation has been greatly improved from a safety standpoint, but not from a control standpoint. The transmission lag between the pressure transmitter and the receiver remains as before.

One solution to this problem, shown in Fig. 8, is to use a force-balance type controller (and a separate recorder) instead of the deflection-type instrument used in the previous illustration. The faster response of the force-balance controller permits a narrowing of the proportional band, which reduces the magnitude and duration of the upsets caused by flow fluctuations. However, the lag between the controller and control valve remain as before. One way of reducing this lag is to mount a relay, or volume booster, on the control valve.

A better solution (shown in Fig. 9) is to mount the controller directly on the control valve instead of in the control room. The recorder remains in the control room as before, and an additional line is run between the recorder and the controller to provide for the control-point setting. This arrangement is as good as, or better than, the valve-mounted pressure pilot, and in addition provides for a record and for remote setting of the control point.

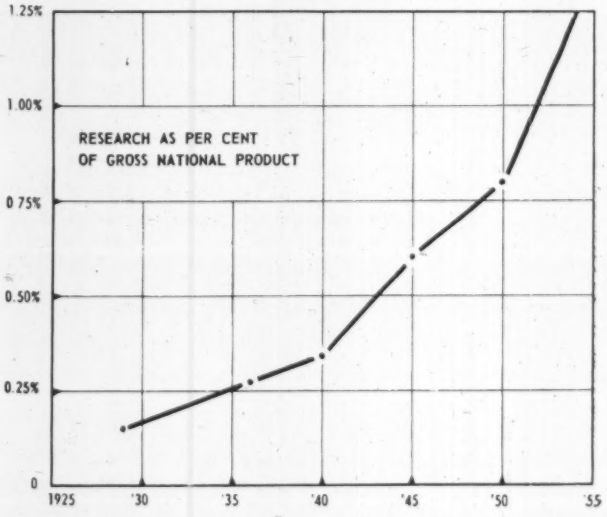
Conclusion

There are many ways of applying pressure control. Optimum application requires knowledge of (1) the differences between direct-operated pressure regulators and instrument-type pressure controllers, (2) the differences between force-balance and deflection-balance controllers, and (3) the process on which they are to be used. By showing the variations of pressure control on a comparatively simple application, this article shows that there is no universal answer to the question: "What type of controller should be used?" The solution must be approached from every angle, including the controllability of the process and the flexibility of the control system required.


ESTIMATED
GROWTH OF
UNITED STATES RESEARCH
(MILLIONS OF DOLLARS)
Source: National Research Council, Steelman Report, Bush Report, and Battelle files.

← Fig. 1. Curve of research expenditures in USA shows dramatic increase between 1940 and 1955.

↓ Fig. 2. Yet research expenditures are still less than 1.5% of gross national product.



Trends in Research

Research will attain a volume of $4 billion in 1955—yet may quadruple before economic limitations appear. This résumé of the research field places the various types of research activities in clear perspective—including commercial contract research laboratories, nonprofit research institutes, university research foundations, company owned laboratories, and trade association laboratories.

CLYDE WILLIAMS
Battelle Memorial Institute

Increasing Significance of Research

IN 1929, expenditures for research in this country amounted to only $160 million. This included industrial research, military research, university research, medical research, agricultural research—all the physical and biological sciences. Even though we thought we were scientific-minded at that time and in the scientific era, research expenditures actually accounted for only 0.15 percent of our gross national product. Last year, in contrast, total research expenditures amounted to $3.75 billion or 1.25 percent of our gross national product—more than 23 times as much dollarwise and nine times as much in relation to gross national product.

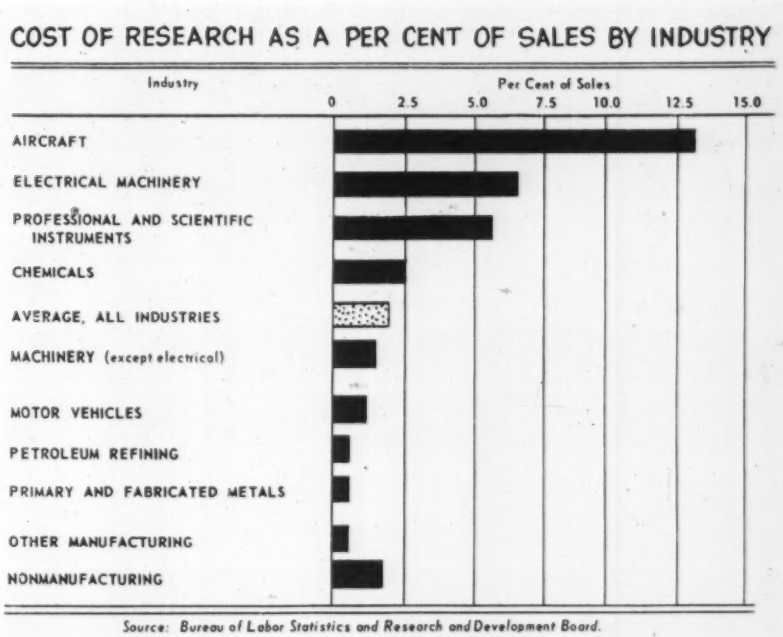
Even as late as 1940, total U.S. research accounted for the expenditure of only $345 million per year. Then, as the impact of war hit our economy, bringing with it problems that had to be solved for our very survival, research grew rapidly. The one-billion dollar mark was surpassed in 1943, and by the end of the war the country was spending for research at the rate of $1.3 billion per year, as shown in Fig. 1.

Research—The New Frontier

Many people thought that when the war was over, industrial research would shrink, along with an expected contraction in industrial output. But industry had learned an important lesson through war research.

The result was that industry took up what slack occurred temporarily in governmental research and added

Abstracted from the *Battelle Technical Review*, August and September, 1955, Columbus 1, Ohio



Source: *Bureau of Labor Statistics and Research and Development Board.*

Fig. 3. Only few industries now devote more than 2.5% of their sales to research. Tremendous potential for greater research expenditures lies untapped.

to it. Whereas governmental research dropped from $880 million in 1945 to $660 million in 1946, nongovernmental research increased from $420 million to $830 million in the same period. The net result was a swelling of the total research activity by $190 million in the first peacetime year. Then, in 1947, governmental research started upward again, to further swell the sharp increases being made in industrial research. The $2 billion mark was surpassed in 1948 and the $3 billion mark five years later. The current rate is at least $3.75 billion, and before the year is over it may reach $4 billion.

The graph (Fig. 2) shows research as a percent of gross national product. It was 0.15% in 1929; 0.34% in 1940; and 0.60% in 1945. It rose to 1.25% last year. As the curve shows, although research is becoming an increasingly large part of the nation's total production effort, it is still a relatively small activity. Great as its benefits are, it is not costly. Its costs are far less than the sales and "nuisance" taxes imposed on goods in many states, and is about as much a drag on the economy as a whole as the cost of a daily newspaper is on the budget of the average American household.

Some industries can support research activities up to one-eighth the amount of net sales. In the aircraft industry, as you can see from Fig. 3, research expenditures run about 13% of net sales; in the electrical machinery industry, they are more than 6%; and in the chemical industry, they are 2.5%. A doubling, tripling, or even quadrupling of present over-all industrial expenditures would seem possible before absolute economic limits are reached.

Change in Basic Character

The rapid growth of the field changed its character also—from one in which the research was done by an individual to one on which a team was required for efficient problem solution.

Small companies cannot provide the manpower and equipment for effective team research. Unless a company has a capitalization of at least a million dollars and gross annual sales of five million dollars, it cannot support much in the way of a research laboratory, although it may have an excellent control and testing laboratory. Some pieces of research equipment cost up to $100,000 or more.

However, more small companies are now actually engaged in scientific research than ever before. They accomplish this seemingly paradoxical feat by contracting with large central laboratories for research on their problems. They buy research services, just as they buy advertising or printing, and in so doing, are spared all the capitalization costs of a large, well-staffed laboratory.

There are three types of organizations that provide contract research service:

Commercial Contract Research Services

There are a great many consulting and commercial laboratories serving industry. Most have specialized fields and the emphasis is on consultation and testing rather than research. A few of the larger ones, however, conduct investigations in diversified fields of applied and fundamental science. One of the largest and best known is Arthur D. Little, Inc., in Cambridge, Massachusetts. This laboratory contracts for the execution of research projects and operates to make a profit. Arthur D. Little has a staff of 800, and in 1954 did $9 million in business.

Nonprofit Research Institutes

The nonprofit research institutes, although fewer in number, have reached a higher development in providing a general research service to industry. Included in this group are the Armour Research Foundation in Chicago; Battelle Institute in Columbus; Mellon Institute in Pittsburgh; Cornell Aeronautical Laboratory in Buffalo; Franklin Institute in Philadelphia; Midwest Research Institute in Birmingham; Southwest Research Institute in San Antonio; Stanford Research Institute in Palo Alto, and the Texas Research Foundation near Dallas. These organizations cover all fields of industrial science, and conduct both applied and fundamental research for industry. Most are substantially endowed or otherwise capitalized, and for their services they charge

Battelle Institute, Columbus, Ohio, largest nonprofit independent research institute, has a staff of 2500 and physical plant valued at $20 million.

actual out-of-pocket expenses, plus a percentage to cover overhead and equipment depreciation. Research is conducted in confidence and all results accrue to the company contracting for the work. In effect, then, these research institutes are the "private" laboratories of each of the thousands of companies they serve—providing confidential research at cost to the company, just as if the laboratory were a branch of the company. They serve both small and large companies alike, and, in addition, handle much of the contract research for governmental agencies.

Mellon is the oldest of the research institutes in point of service to industry, its organization antedating Franklin Institute's entry into industrial research by twelve years. Mellon is an outgrowth of a scheme of industrial fellowships introduced by Robert K. Duncan at the Unifersity of Kansas in the early years of this century. Duncan saw the need for training students in industrial research methods and also felt that industry at that time was hampered by lack of facilities for research. At the invitation of A. W. and R. B. Mellon, he came to the University of Pittsburgh in 1910 to establish a department of industrial research. Three years later Mellon Institute was endowed and organized as the first independent nonprofit research institute in the United States.

Mellon originated many of the contract research practices in use today and did much of the pioneering educational work on the value of industrial research.

Battelle is the largest of the not-for-profit independent research institutes, with about 2500 staff members and a physical plant having a replacement value well in exces of $20 million. Its current volume of contract research is at the rate of $16 million annually. In a typical year, it supplies research services to 500 or more private companies, associations, or organizations. The total clientele of all the research institutes is nearly 3000 companies.

University Research Foundations

The third type of research organization serving industry is the research foundation associated with a university. These foundations operate similarly to the independent research institutes, conducting research on a cost basis. Some have separate management and employ full-time permanent staffs. Others are responsible to the management of the university and use faculty members and graduate students either in part or exclusively for the execution of industrial projects. A few have their own laboratories, although the majority use customary university facilities.

Typical of these are the Alfred University Research Foundation, the Engineering Research Institute of the University of Michigan, the Purdue Research Foundation, the Division of Industrial Cooperation of the Massachusetts Institute of Technology, and The Ohio State Research Foundation. Some of these organizations conduct research running into millions of dollars per year. Together, the university foundations add strongly to the nation's research might and industry's potential for progress. The services of these foundations are implemented further by the industrial research conducted in the graduate departments of universities, mainly as an educational function. Altogether, some 2800 universities and colleges provide research assistance in one way or another to industry.

Contract research, then, is the mechanism by which the requirements in men and equipment for modern team research are fulfilled for a large segment of industry. Contract research supplements the research conducted in company-owned laboratories—of which there are some 3000—in providing industrial progress. The growth of contract research, its evolution and development, and its extension to more and more industries is the most significant trend in respect to research facilities in America today.

Mellon Institute, Pittsburgh, Pa., is the oldest of the research institutes in point of service to industry.

Stanford Research Institute, Menlo Park, Calif., occupies about one third of the former army hospital.

Company-Owned Laboratories

I should point out that this does not lessen in any respect the work done by company-owned laboratories. But with the complexity of modern technology, fewer companies can afford adequate private research facilities. The biggest laboratories are still the laboratories of private corporations, such as those of American Telephone and Telegraph, Du Pont, General Electric, Standard Oil of New Jersey, Union Carbide and Carbon, American Cyanamid, Allied Chemical and Dye, Socony-Vacuum, and Monsanto. Du Pont spends about $61 million a year for research; American Telephone and Telegraph, nearly $24 million; Standard Oil of New Jersey, about $30 million; and Union Carbide and Carbon, around $35 million. The research budgets of the others named ran well in excess of $10 million. The Bell Telephone Laboratory has a staff of more than 6000 people and is thus 2½ times as large as Battelle, the largest contract research organization.

But, it is significant that as these "captive" laboratories grow and become more responsive to the needs of their companies, they too, diversify and tend to embrace more and more of the sciences and technologies—the better to use the cooperative or team research approach to the solution of problems. Thus the Du Pont Laboratory employs metallurgists, mechanical engineers, and electrical engineers as well as chemists and chemical engineers; and the big metals companies employs experts in many phases of science other than metallurgy.

There is a limit, of course, to how far it is wise for a company laboratory to diversify. Diversity to the extent of that of the research institutes would be impractical. But industrial laboratories can extend the range of their interests by using the services of research institutes. This they do, and large companies with expensive laboratories of their own are actually the major clients of organizations like Battelle, Armour, and Mellon.

Trade Association Laboratories

To round out the picture of modern research facilities, we should mention trade association laboratories. There are some 2000 trade associations of national or regional scope in the United States and approximately 10,000 of state and local importance. At least 30 of these associations maintain their own laboratories. In these laboratories, the problems of general interest to the industries concerned are investigated. Trade association research is designed to promote an industry as a whole, rather than individual companies, and thus to place industry in a better position among competitive industries.

The same problems of capitalization and maintenance of facilities apply to trade associations as to companies. For this reason, most associations use contract research rather than building and staffing their own laboratories. As new associations are formed for the purpose of research—frequently called research associations—or as older trade associations take up research as one of their functions, they usually look to contract research organizations for their laboratory work. This trend, as opposed to the older practice of setting up trade association laboratories, is enabling more rapid progress in the solution of industry-wide problems, and thus is accelerating industrial progress generally.

ELECTRONIC

CHARLES F. KEZER

and

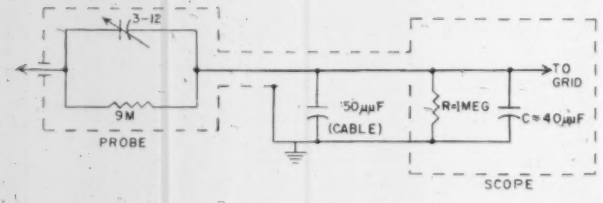
MILTON H. ARONSON

CONVENTIONAL OSCILLOSCOPE PROBE PRESENTS IMPEDANCE OF 10 MEGOHMS + 13 UUF

This simple probe circuit, supplied with a popular commercial wide-band oscilloscope, allows waveforms to be observed on circuits which would be adversely affected by input loading.

Input impedance of the scope (without probe) is one megohm in parallel with capacitance of 40 uuf (shown in dotted box in diagram). As 40 uuf corresponds to a reactive impedance of about 1 megohm at 4 kc (and higher at lower frequencies), the probe is not essential for many tests. When it is necessary to use a shielded input cable, however, cable capacitance adds 50 uuf (typically) to the scope input capacitance, as shown. Further, even the 40 uuf capacitance may be too large for tests at high frequencies. Therefore, the probe shown is designed to give a total impedance (probe plus oscilloscope) of 10 megohms in parallel with only 13 uuf.

The shielded probe housing contains a 9-megohm resistor in parallel with a ceramic trimmer capacitor, which



is adjusted to 10.0 uuf. An additional 4 uuf is contributed by the capacitance of the nose to the case. The probe, together with the scope input resistance (1 megohm) and scope and cable capacitance (90 uuf), may be considered as a capacitance voltage divider in parallel with a resistance voltage divider. The trimmer capacitor in the probe is adjusted so that high frequencies are attenuated by the capacitance divider in the same ratio as dc is attenuated by the resistance divider, and the probe then passes all frequencies equally. With ideal components, the attenuation is independent of frequency if the capacitive reactances are in the same ratio as the resistances. Inductive effects due to wiring can be made insignificant. Poor quality capacitances or resistances are the common sources of significant distortion.

At sufficiently high frequencies, but beyond the useful bandwidth of most oscilloscopes, resonant effects in the probe cable increase the frequency response and add overshoot and ringing to a square wave.

As a rule, the effect will be insignificant until the signal frequency exceeds, say, one fourth to one third the ringing or resonant frequency of the probe cable terminated in the shunt capacitance of the oscilloscope. Thus the length of the probe cable has a maximum for satisfactory performance on a given oscilloscope. The probe above rings at approximately 60 megacycles, too high to be observed unless the response of the oscilloscope extends to this frequency.

When probes are to be used with very wideband oscilloscopes, a non-ringing probe cable is required. Probes with such cable are commercially available. The inner conductor is a high-resistance wire which eliminates overshoot and ringing of a transmitted square wave. These probes (designated the P400 series by this manufacturer) have an inherent rise time of 3 to 5 millimicroseconds; the frequency response is down approximately one db at 30 megacycles. These probes are available in several attenuation ratios, and present capacitances of only 2.5 uuf at the higher attenuation ratios.

Adjustment of the trimmer capacitor in these probes is made readily by applying a square-wave input, and adjusting for minimum tilt and overshoot in the wave as viewed on the scope. Although these probes provide an increase in input impedance, this higher impedance is accompanied by signal attenuation; that is, the impedance is obtained at the expense of gain. (The attenuation ratio inherent in this type of probe often is called "attenuation factor.") A probe which provides a low input capacitance, while introducing less attenuation, is shown in the next circuit.

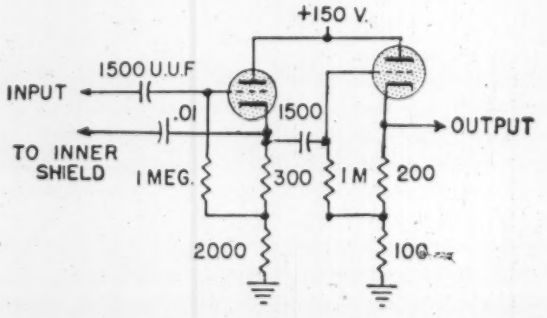
Frequency Response: Adequate for oscilloscopes having response from 0 to 15 Mc. (Probe shown "rings" at 60 Mc).

Source: Tektronix Long Form Catalog, Tektronix, Inc. Sunset Highway and Barnes Road, Portland 7, Oregon.

PROBE WITH DRIVEN SHIELD REDUCES INPUT CAPACITY TO 4.5 UUF

As shown in the preceding circuit, a conventional voltage-dividing probe obtains high impedance at the expense of gain, providing an input capacitance of perhaps 15 uuf at the expense of attenuation (or attenuation factor) of 10/1. This probe uses two cathode followers to obtain an input capacity of only 4.5 uuf, and attenuates the signal by a factor of only 1.6/1 (at midband). Loss is due to loss in the two cathode-follower stages.

First stage of the 6211 subminiature dual-triode tube is designed for low input capacitance; second stage provides low output impedance to drive a coaxial line to an oscilloscope. A further reduction of input capacity is obtained by a double shield around the probe. Outer shield



CIRCUITRY

The circuit is the heart of all electronics. Here are four more basic and interesting circuits. Unless marked, resistors are in ohms, capacitors in microfarads.

is grounded; inner shield is driven from the cathode of the first stage. As inner shield follows the signal, effective capacity is reduced from 6.2 uuf (obtained when this shield is grounded) to 4.5 uuf. Probe was built in a cylinder 2 inches OD by 6½ inches long.

Linear operation is obtained for 10-microsecond pulses of −6 to +10 volts amplitude.

Pulse response: Rise time is 0.08 usec; square wave is down 5% at 115 usec.

Frequency response: Down 3 db at 220 cps and 40 Mc (assuming output load of 80 uuf consisting of 10-uuf stray capacitance, 30-uuf due to 2 ft of coax cable, plus 40 uuf due to oscilloscope input capacity). Note: db = 20 log E_o/E_i.

Source: G. L. Schultz, I.B.M., Poughkeepsie, New York; also *Review of Scientific Instruments*, November, 1953.

NONRINGING PROBE USES CATHODE FOLLOWER TO OBTAIN Z_{in} OF 12 MEGOHMS + 5.5 UUF

The commercially available probe shown at the right (manufacturer's type P170-CF) has still wider frequency response and simpler circuitry, but slightly higher input capacity than the preceding circuit. Ringing of the coaxial cable is eliminated by terminating the cable in its characteristic impedance (resistive) of 170 ohms. At the probe end of the cable, the subminiature 5718 tube develops a resistive output impedance of 170 ohms; a cathode resistor of equal value terminates the other end of the cable in the scope. Properly terminated at both ends in its characteristic impedance, the cable is nonresonant and hence free from ringing.

Improved frequency response is obtained since the cable presents a resistive impedance instead of a capacitive load; furthermore, the low impedance level reduces the shunting effect of the scope input capacitance.

Since the 5718 tube is working into a load impedance equal to its own internal impedance, voltage gain is only 0.5.

Input impedance: 12 megohms shunted by 5.5 uuf.

Rise time: Less than 0.003 usec.

High-frequency response: down less than 0.5 db at 65 Mc.

Low-frequency response: down 3 db at 15 cps.

Output: Linear to 1% on positive-going signals of 0.5 v, and to 2% on negative-going signals of 0.5 v.

Gain: 0.5.

B Supply: 10 ma at 120 v dc.

The P500-CF probe shown has response (½ db) to 10 Mc on an oscilloscope with input capacitance of 45 uuf. Pulses with rise time of 0.04 usec are not perceptibly slowed.

Source: Tektronix, Inc., Portland 7, Oregon.

WATER FLOW SAFETY INTERLOCK

This circuit was developed to protect an electron microscope against interruptions in the supply of cooling water to its diffusion pump. Commercially available interlocks do not operate on the small flow (3 cc/sec) required.

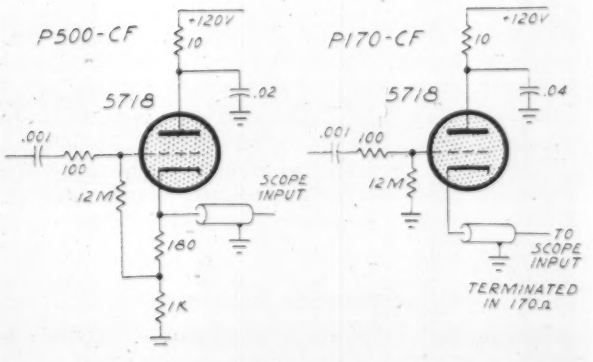
Resistance of the stream of tap water flowing from the diffusion pump was measured and found to be constant at 0.1 megohm. Grid of the triode-connected pentode section of the 117N7 tube is operated from a voltage divider consisting of the water resistance and a 1-megohm shunting resistor. When water is flowing, the grid operates with small bias (grid is returned to cathode via gap), and plate current holds the relay closed. When water flow is interrupted, however, positive cathode bias developed across the 1K leg of the power-supply bleeder cuts the tube off and the relay contacts open, breaking the main power circuit to the electron microscope.

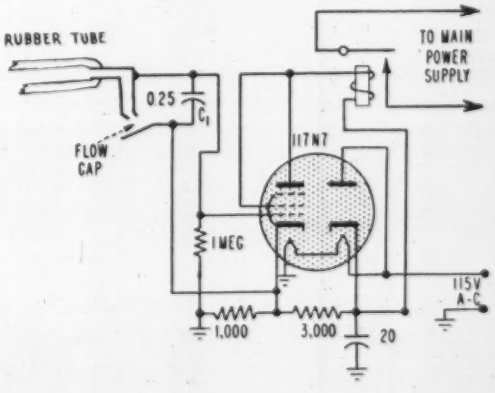
B-supply voltage is obtained from rectification in the diode section of the 117N7 tube. As the tube heater is constructed for 117 v operation, no heater transformer is required.

Water gap is constructed to prevent retention of a drop of water by surface tension. Leakage paths due to moisture must also be avoided. Capacitor C_1 was added across the flow gap to provide a longer time constant; otherwise the relay chatters with every small air bubble passing the contact gap.

Relay Rating: Spst, make on operate. Coil operates on 50 ma or less. Contacts must handle up to 3 amps.

Source: Robert W. Woods, College of Medical Evangelists, Los Angeles, Calif.; also *Electronics*, May 1954.





Measurement of DAMPING

ALVIN B. KAUFMAN

Northrop Aircraft Co., Inc.

The natural frequency and degree of damping of an electrical structure can be done rapidly and simply by imposing a step-type forcing function, recording the response on a high-frequency recorder, and noting the overshoot and frequency of induced oscillation. Of particular value are the clear definitions of all important parameters, and distinction between natural frequency (f_n), resonant frequency (f_r), and frequency of maximum forced amplitude (f_m).

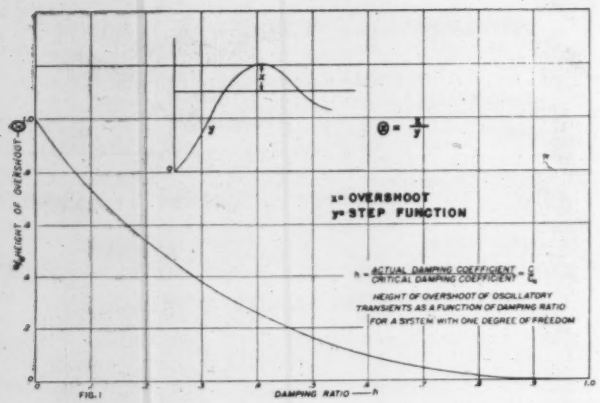

HEIGHT OF OVERSHOOT
x= OVERSHOOT
y= STEP FUNCTION
h = ACTUAL DAMPING COEFFICIENT / CRITICAL DAMPING COEFFICIENT
HEIGHT OF OVERSHOOT OF OSCILLATORY TRANSIENTS AS A FUNCTION OF DAMPING RATIO FOR A SYSTEM WITH ONE DEGREE OF FREEDOM
DAMPING RATIO — h

Fig. 1. When moving element is exposed to a forcing step function (y), overshoot (x) occurs if damping ratio (h) is less than 1. Curve shows % overshoot vs damping.

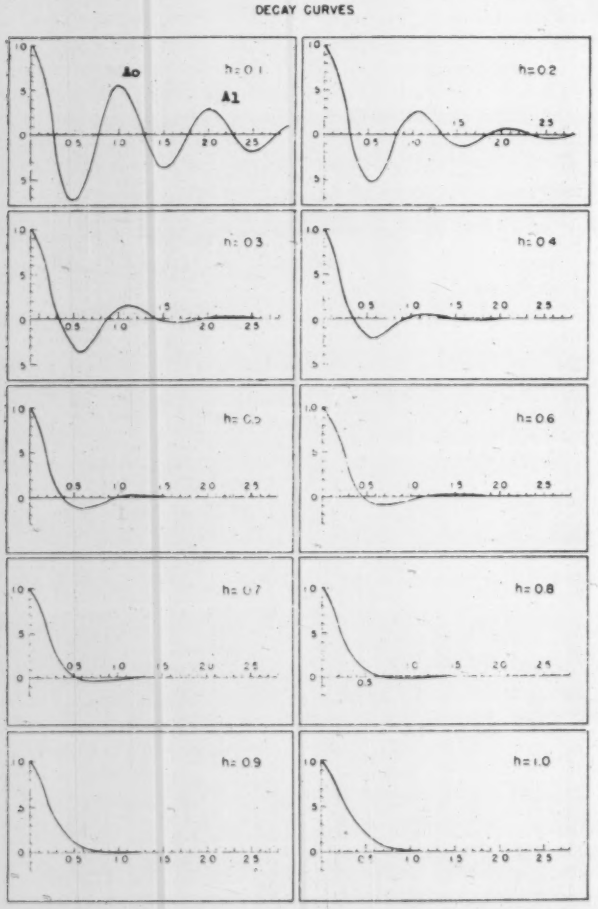


Fig. 2. Response of moving element to step-type forcing function for various values of damping ratio (h) less than 1.0.

DETERMINATION of the natural frequency and degree of damping in structures, galvanometers, accelerometers, and other electrical elements can be done simply, rapidly and accurately if the proper parameters and test configurations are understood.

Damping and natural frequency should be defined carefully because the terminology of many writers has been ambiguous and misleading.

Damping ratio (h) is usually defined in terms of the response of a moving element after application of a forcing function. The forcing function used is either a step function (step-type sudden change) or a sinusoidal forcing function (which is varied through some given frequency range).

Fig. 1 illustrates a typical response to a step function, showing that overshoot can occur. Fig. 2 shows typical responses to a step function for various degrees of damping. Fig. 3 shows a common method for illustrating the response to a sinusoidal function.

Critical damping ($h = 1.0$) is defined as that value at which the output of the element has the maximum speed of response *with zero overshoot* upon application of the step function. This has also been stated as that point when the motion of the moving element or seismic mass is just becoming nonoscillatory.[1] Critical damping is shown last in the family of decay curves in Fig. 2.

Over-damping ($h>1$) also prevents overshoot, but the response is slower than that when critical damping exists.

The degree of damping determines the frequency-response range of accelerometers or galvanometers, and affects the degree to which structural resonance may cause failure.

Frequency Response

The amount of damping determines the frequency reponse range of an accelerometer, galvanometer, or any

and NATURAL FREQUENCY

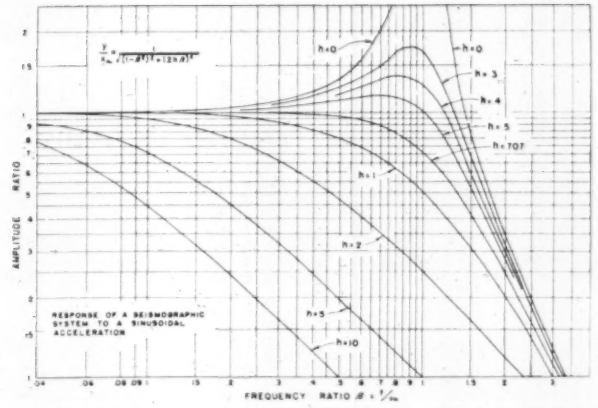


Fig. 3. Family of curves showing frequency response of moving element exposed to sinusoidal forcing function. Note that damping factor of 0.64 gives flat frequency response to 67% of natural frequency of element.

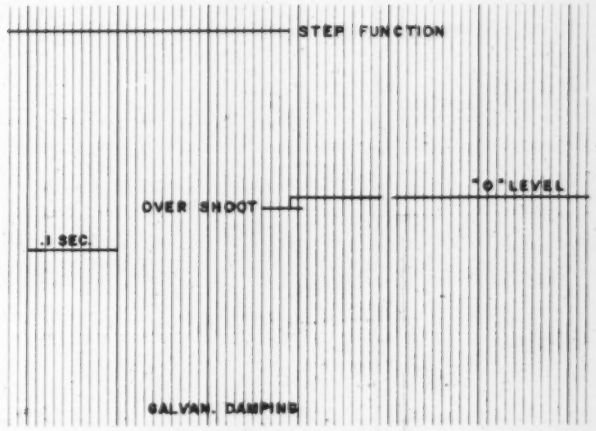


Fig. 4. Step function for testing response of galvanometer was obtained by interrupting a direct current through the element; element returns to its normal 0 level.

moving element, and also affects the degree to which structural resonance can cause failure.

Fig. 3 shows the effect of damping on the frequency response of a moving element. The *amplitude ratio* is the ratio of the excursion of the element to the amplitude of the forcing function (in this case a sinusoidal one). The *frequency ratio* is the ratio of the frequency of the applied sinusoidal forcing function to the natural resonant frequency of the element.

It is usually desirable to have a flat frequency response —that is, to have the element respond equally to all frequencies. Overdamping causes serious loss of frequency response, as shown by the great departure (from horizontal line 1) of all curves $h>1$. (The horizontal line indicates flat response, or equal output/input ratio.)

Note also that underdamping results in oversensitivity (caused by resonance) as the impressed frequency approaches the natural resonant frequency of the element.

Optimum frequency response[2] over the widest frequency range has been determined through experience to be approximately 64% of critical ($h = 0.64$). As shown in Fig. 3, by damping a galvanometer or accelerometer to 64% of critical, it is theoretically possible to maintain uniform, flat frequency response ($\pm 2\%$) from zero to 67% of its natural frequency. As damping rarely can be set so precisely, many manufacturers set a limit of 60% of natural frequency and an amplitude tolerance of 5%— that is, they guarantee that the element will have flat response, within 5%, up to 60% of its natural frequency.

Measurement of Degree of Damping

The calculations and procedures for determining the degree of damping of an electrical element can be done by two methods. The resulting accuracy, however, depends on simulating the actual operating configuration of the element. For example, galvanometers or accelerometers receiving some damping from external load resistors should be wired accordingly. The galvanometer makes no distinction between driving-source resistance and damping resistance, but derives its damping from their combinations. Therefore, in order to avoid over- or underdamping, it is desirable to know the output impedance of the device whose output is to be recorded, as well as the damping requirements of the galvanometer, so that the proper damping network is used. (If the output impedance is greater than the required damping resistor, a shunt resistor should be used, and if less, a series resistor is required.)

A structure, galvanometer, accelerometer, seismic mass or any other electrical element can be set into motion in numerous ways. Where the structure, pen arm, or mass is directly available, it may be manually moved and then released, effecting a step input function.

In other cases a light string or wire is attached to the structure with a suitable weight; the string is then cut. In some instances this may result in a shift in the zero axis due to the permanent set in the structure; if this occurs a correction to the data must be made.

For galvanometers and many electrodynamic vibration pickups, a d-c input may be used to offset the moving element, and then shut off (being sure that the damping networks are not affected) to secure a step function to induce free oscillation. This was done in Fig. 4 to obtain the step function response of a Consolidated galvanometer.

With strain-gage accelerometers and potentiometer accelerometers, a step function may be produced by slapping it down on a felt-padded table. Care must be taken to prevent rebound. It is preferable, but not always required, to heavily weight the accelerometer case because all accelerometer measurements are based on the mass ratio between the seismic mass and case. This weighting also helps prevent rebound. Fig. 5 illustrates this method as used with an Edcliff swept pot accelerometer.

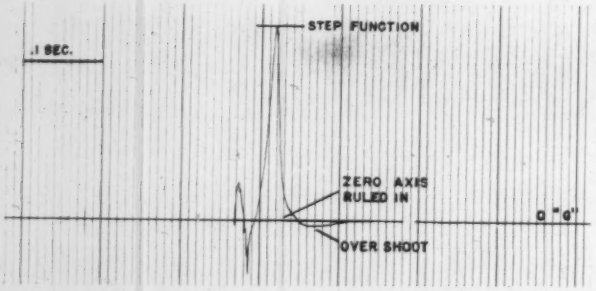


Fig. 5. Step function for testing this accelerometer was obtained by slapping accelerometer on a felt-padded table, and preventing rebound.

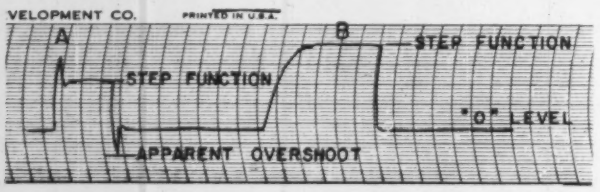


Fig. 6. Same instrument appears overdamped (A) or underdamped (B) because voltmeter was left connected across input to the pen amplifier when step function was introduced.

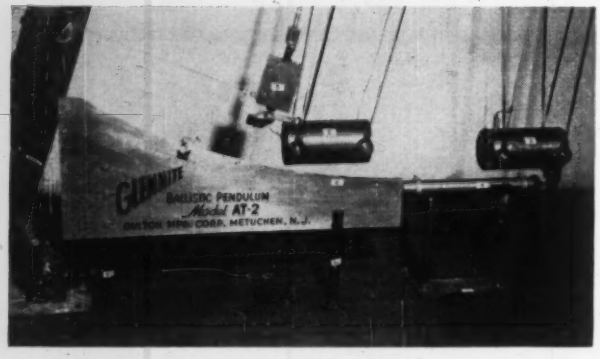


Fig. 7. Ballistic pendulum may be used to produce step function; the impact shock will be sharp step function unless rebound occurs.

A ballistic or torsion pendulum may also be used to produce the step function. With the ballistic pendulum the shock produced at impact may be assumed to be a step function unless excessive rebound occurs. The shock at impact is both an acceleration impulse and a velocity step function. Typical of this equipment is the Gulton AT-2 unit shown in Fig. 7.

In the calibration of angular accelerometers, a torsional pendulum is best suited. The torsional pendulum affords an angular acceleration varying sinusoidally.[3] In practice, the pendulum, with the angular accelerometer mounted on it, is deflected from rest through a known arc and then set free. Friction in the system must be of minor significance. Damping ratios of less than unity may be studied by analysis of the record of the first excursion when the torsion pendulum is released. The suddenly applied cosine change in angular acceleration may, in this instance, be considered a step function and the damping ratio determined by the amount of overshoot (as shown in Fig. 1). The natural frequency of the accelerometer must be high compared to the pendulum frequency for the use of this technique. This method may be used also with linear accelerometers.

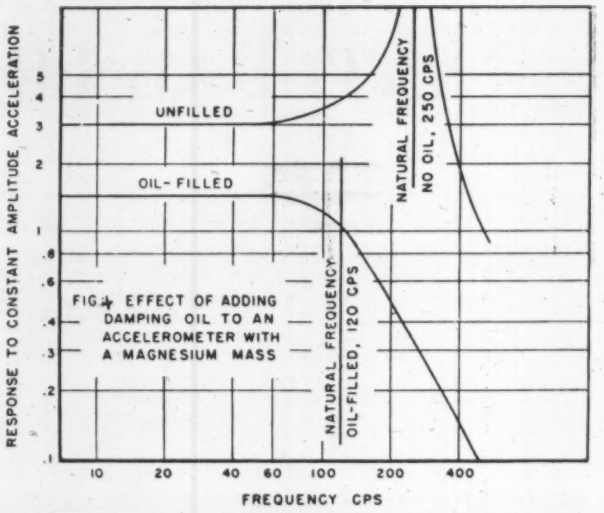


Fig. 8. Response of oil-damped accelerometer shows lowering of natural frequency when oil damping is used. This is due to increase of the effective mass of the oil-damped accelerometer, which now must "pump oil" when it moves.

In order to secure valid damping data the measurement equipment itself must be used with care. If a recording oscillograph is used, the oscillograph galvanometer must have proper damping and a frequency range much higher than the expected frequency of the accelerometer or structure under test. For these reasons, pen-type recorders are generally not satisfactory for damping tests. Oscilloscope-camera recording equipments are better suited as they have an almost unlimited frequency range. As some oscilloscopes or amplifiers have overshoot when subjected to a step function change, the equipment used must be selected to be free from this malfunction.

Calculation of Damping

In analyzing the records to determine damping, two methods are used. One is known as the *decay method*; the other as the *step-function* method.

The decay method[4] is based on the measurement of the amplitude decay of a damped wave train. Although the equations generally used are for "n" number of oscillations, the following equation is based on the ratio of amplitudes of the envelope at the peaks of any two successive full waves. The decay-method equation is:

$$\text{critical damping} \times 100 = \frac{\log (A_0/A_1)}{\sqrt{1.862 + [\log (A_0/A_1)]^2}}$$

where log is to the base 10. The answer will in all cases be less than 100% ($h<1.0$). Fig. 2 indicates the limitations of this method. Note that it is impossible to measure the ratio of amplitude of two succeeding wave trains where h is larger than 0.3. Thus, this method is limited to components or structures that are highly underdamped.

Another method *must be used* where $h \geqq 0.3$. This method is the *step-function* procedure[3]. Figs. 4 and 5 show the result of producing a step function on a galvanometer and an accelerometer, respectively. The accelerometer was shock excited; the galvanometer had a d-c potential removed (damping R left connected). The equation $\Theta = \frac{x}{y}$, where y is the amplitude of the step function and x is the amplitude of the overshoot, must

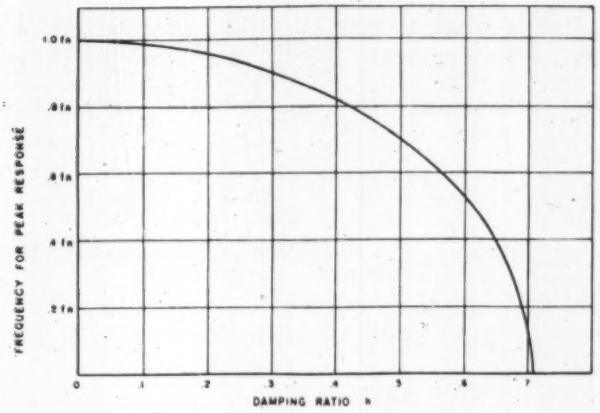


Fig. 9. If sinusoidal signal of various frequencies is applied to circuit with a natural resonant frequency and damping, peak response will occur at some frequency less than the natural frequency. Curve shows frequency at which peak response occurs vs damping ratio (h). Frequency of this maximum forced amplitude is called f_m.

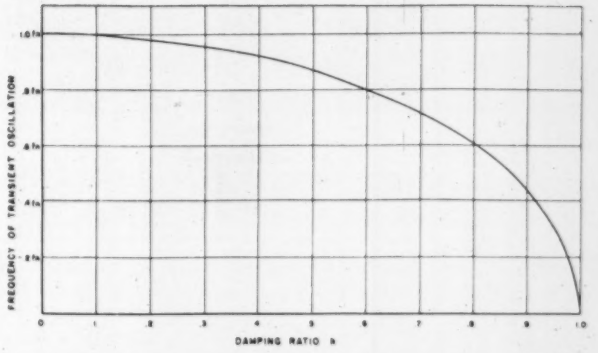


Fig. 10. If system is forced into a transient oscillation by imposition of a step function, frequency of transient oscillation will depend on damping ratio (h). Curve shows frequency of transient oscillation vs (h). Resonant frequency due to transient shock is called f_r.

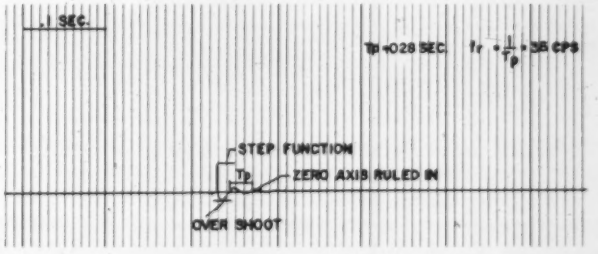


Fig. 11. Damping and f_r are determined in one step by noting overshoot and T_p.

be used with the graph shown in Fig. 1. Here the computed value Θ is referenced to the graph and the corresponding damping determined by co-ordination. This procedure is straightforward, but precaution must be used. Referring to Fig. 6, this pen recorder apparently looks highly underdamped at A or overdamped at B. Point A indicates that the true damping $h \leqq 1.0$. The apparent underdamping at Point B was due to leaving a voltmeter connected across the input to the pen amplifier when the d-c signal was removed. As the meter oscillated to a stop, it behaved as a generator and introduced a modulation into the amplifier. During all tests and calibrations, *it is imperative that no instruments be connected on any line in the measurement system.*

Definition of Natural Frequency

Determination of natural frequency is more complex and involved than determination of damping. Here again, ambiguous terminology requires review of definitions.

The meaning of "Natural Frequency"[2,6] is related to several other terms in use: undamped natural frequency, damped natural frequency, resonant frequency, etc. It is evident as one reads the literature that a difference in usage exists.

In a system containing a mass (M) and a spring restraint (K), the natural frequency is given by:

$$2\pi f_n = \sqrt{K/M}$$

Damping in the system has nothing to do with the natural frequency (f_n), and the damping can be varied at will without altering f_n. In the case of viscous damping[7] the real mass of the pickup must move oil when it is displaced, and the moving oil has kinetic energy. Hence the effective mass is increased, and we commonly say that the mass pumps oil. In the design of oil-damped accelerometers (Fig. 8) this lowering of the natural frequency is usually minimized because the highest possible natural frequency is wanted. This should not be construed to contradict the previous statement that f_n is independent of damping, even though Fig. 4 indicates a frequency shift.

In the previous discussion, it was assumed that the damping could be varied without affecting either the spring constant or the suspended seismic mass. Such is the case with magnetic damping, where the magnetic field or source impedance can be varied without affecting the other parameters. Such is *not* the case with fluid damping, and therein lies a trap for the unwary. If the fluid is removed from a fluid-damped instrument, the free oscillation and the natural frequency of the unit *without* fluid may be determined. If the fluid is replaced, one unfortunately has a different system with a new value of mass, and the previously determined natural frequency does not apply to it—*and has no meaning* when used to describe it. The addition of fluid has created an entirely new system with new parameters and a new natural frequency, *and the damping still has nothing to do with it.*

The terms "damped natural frequency" and "undamped frequency," whatever they may be intended to mean, appear to have no usefulness in the specification of the characteristics of instruments, structures, etc. The term "natural frequency," however, is adequate and unambiguous as applied to the operating configuration of an instrument or structure.

Measurement of Natural Frequency

If a sinusoidal input of constant amplitude is applied to the instrument, and the frequency varied, a frequency (f_m) will be found at which the instrument response is at a maximum. *The frequency at this maximum is not the natural frequency* f_n. Only if the damping is zero does the maximum response occur at the natural frequency. Figs. 9 and 10 indicate the relation of f_n to the apparent resonant frequency for a given damping coefficient and for sinusoidal or transient forcing of an instrument.

As shown in Fig. 9 for sinusoidal forcing, as the damping is increased, the frequency at which peak response occurs is lowered and, at a damping ratio of

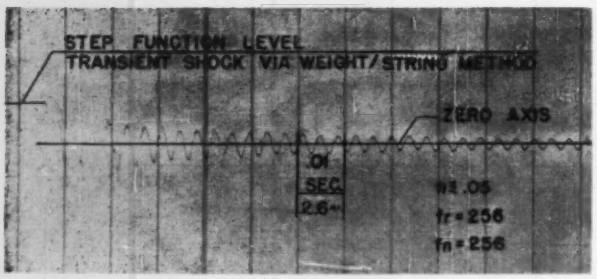


Fig. 12. Step-function transient shock is imposed on highly undamped structure via weight-string method. Examination of record shows damping factor, f_r, and f_n.

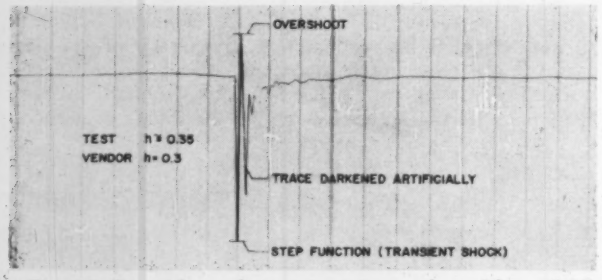


Fig. 13. Test of accelerometer gives value of h = 0.35.

$1/\sqrt{2}$ the peak response is at zero frequency. For greater damping, no real maximum exists at all. Fig. 3 also indicates this *apparent* lowering of natural frequency.

If the instrument is displaced (step function) and then allowed to execute a typical damped transient (Fig. 10) it may be found that the transient decay is oscillatory (if $h \leqq 0.6$) and a frequency (f_r) may be assigned to it. This frequency may be found by the equation:

$$f_r = 1/T_p$$

where T_p is the time for one complete sinusoidal wave. *This is not the natural frequency.* As with the sinusoidal forced instrument, only at zero damping is the frequency of the oscillatory transient the same as the natural frequency. As the damping is increased, the frequency of oscillation *decreases* and, at a damping ratio of unity, the oscillatory nature of the transient disappears entirely.

The natural frequency and apparent natural frequency (sometimes referred to as resonant frequency) are the same only under the unique condition in which there is no damping[2, 4]. This may be of academic interest where a structure may be exposed to vibrational stress in the resonant range. However, the natural frequency (f_n) is required for use in computating the flat frequency range of a glavanometer or accelerometer.

Frequency of maximum forced amplitude (f_m), as referred to in some publications[2], differs from resonant frequency (f_r) in that it is the point of maximum amplitude when forcing is used; f_r, as determined by transient shock, gives a different apparent natural frequency. Figs. 9 and 10 indicate the correction to secure f_n (for the two methods of test) for various degree of damping.

Natural frequency may be found by first determining the % of critical damping and then determining f_r or f_m. The f_r or f_m frequency is then corrected (by using the referenced graphs in Figs. 9 and 10) to f_n.

Needless to say, the natural frequency may be difficult to determine in a properly damped instrument, and thus a critical attitude should be maintained toward measurements made by undisclosed techniques.

As indicated in Fig. 2, the transient shock method of determining f_r can be used only where $h \leqq 0.6$; otherwise an insufficient wave train exists to determine the

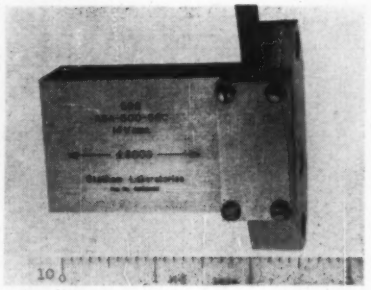


Fig. 14. Typical strain-gage transducer for which independently derived damping and natural frequency data may be required.

period of oscillation for one complete alternation of the wave. When a damped wave train of sufficient duration does exist:

$$f_r = 1/T_p$$

where T_p is the time in seconds for one full wave. Fig. 11 illustrates an ideal condition wherein damping and f_r are determined in one step. Note that damping is about 0.3 and that although f_r is 36 cps, correction by Fig. 9 indicates an f_n of 37.9 cps.

Where $h \geqq 0.6$, no damped wave train is available for f_r determination. The application of a sinusoidal forcing function can be applied to the galvanometer or accelerometer for the determination of f_m. If one is misled into believing that this apparent natural frequency (f_m) is the true resonant frequency (f_r) or natural frequency (f_n), serious errors will result. For example, in a galvanometer with f_n of 1000 cps (damped to 0.64), the apparent natural frequency (f_m) will be about 420 cps even though the galvanometer is usable ($\pm 2\%$) to at least 600 cps, due to its rising characteristics with the subject damping, as shown in Fig. 3.

In structural analysis where a pick off of some nature must be used to determine movement, a bonded strain gage, a strain-gage bending beam, or accelerometer may be used, providing their effect on f_r and damping of the structure is negligible and that they themselves do not introduce other parameters into the measurement. The best technique is the use of capacitive or magnetic-field displacement devices which require no intimate contact with the structure. With structure analysis some care must be taken to examine the effect of the assembly on h and f_r, or with addition of air loads.[4] These details are beyond the scope of this review.

In conclusion, it may be stated that there are three frequency parameters which are valid and unambiguous —f_n, f_r and f_m. If used and defined as described, confusion should be minimized.

As detailed procedures for determination of the parameters in question are subject to many variables, information on equipment setups would be of little value in this discussion of techniques.

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DIGITAL AUTOMATION

The basic logical network is the diode matrix, which can examine any given number of programmed premises and make any number of desired decisions. Here is a clear and thorough introduction to this basic digital technique. This is the third in this series.

MARTIN L. KLEIN
FRANK K. WILLIAMS
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THE LOGICAL NETWORK

In order to perform logical and arithmetic operations, use is made of a logical network. This network arrives at a unique and distinct conclusion from a given set of premises, unfailingly. It depends on a *program*, or schedule, which is instituted by the designer for its operation.

Once programmed, a logical network can take care of any set of premises to arrive at the conclusion desired *for this set of premises*. For example, suppose we desire to ring a bell when a tall blue-eyed blonde girl passes a certain point. This is essentially a problem in logic in waiting at the given point and examining each girl who passes the point. We first might check hair color and discard all brunettes and redheads. Secondly we might check the height of the girls and eliminate all short ones. Finally, we reject all that do not have blue eyes. If, however, a girl meeting the premises of blue eyes, blonde hair, and tallness passes the point, a bell rings. This is a logical network which has used the three premises (height, hair color, eye color) to arrive at the conclusion (ring bell).

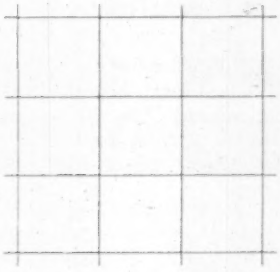


Fig. 3-1. A matrix consists of rows of vertical wires insulated from rows of horizontal wires.

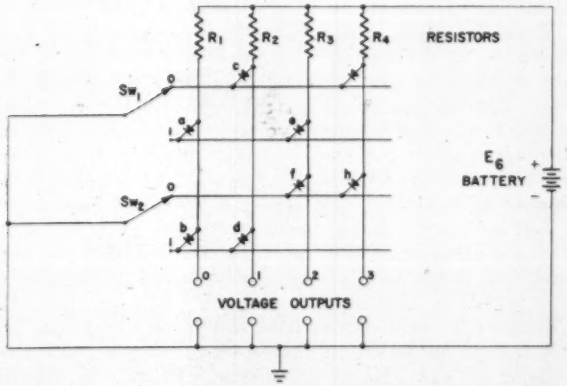


Fig. 3-2. A basic 4-decision diode matrix comprises 8 diodes and 2 switches. When switches are as shown, only line 0 is activated; and only output 0 shows output voltage. Matrix now responds only to 00 condition. By switching the top switch, the voltage output can be switched to output 1, representing the 01 condition. Switching both switches transfers the output to output 3, representing the 11 condition. Hence switches control outputs 0, 1, 2 or 3—representing binary conditions 00, 01, 10, and 11. Advantage of diode-matrix switching of this type is that switching speeds can exceed millions per second. Also, the matrix is a decision-making element which indicates the condition of the inputs (switches).

Another logical network performs the steps in a tic-tac-toe game to prevent a human player from winning the game. Here the premises are the various plays made by the human; the answer is a move made by the machine. Each set of plays represents a set of premises, and the next machine move is a logical result which is designed to prevent the human player from winning the game.

In the automation of a process, the premises are the succession of temperatures, displacements, pressures, and so on. These are examined by the logical network, which in turn takes the necessary action to lead the process to the next step. In each of these operations, the logical network examines the premises and causes the next step to take place as a necessary consequence of these premises. This is accomplished simply with the use of a network of diodes known as a *diode matrix*.

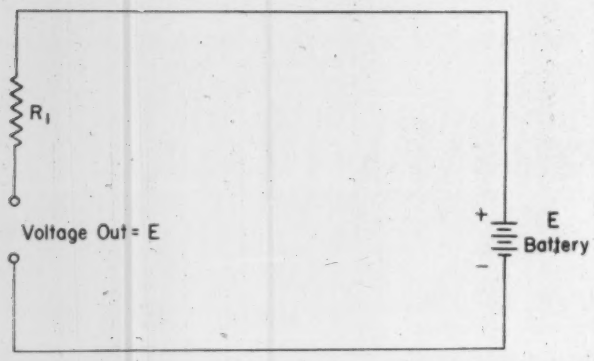
The Diode Matrix

The diode matrix is made up of a crosshatch of wires in two planes (Fig. 3-1). The horizontal wires are insulated from the verticals. Diodes are used to interconnect the horizontal and vertical wires in a way to perform the required logic.

A diode is an element that conducts in one—the forward—direction, and is an insulating element in the reverse direction. It carries current only in the forward direction. Various materials are used to manufacture diodes; selenium rectifiers are common, as are germanium crystal diodes.

The logical network also uses resistances which, with the diodes, form a series of dynamic voltage dividers. The diodes are placed on the matrix in a prescribed manner according to the premises to be set in, and the result desired from, the matrix. This is the program for the action of the matrix, or *matrix programming*.

Fig. 3-2 shows a matrix which uses eight diodes, two



Fg. 3-3. Electrical circuit of vertical line 0 when switches are in position 00; E_o appears at output.

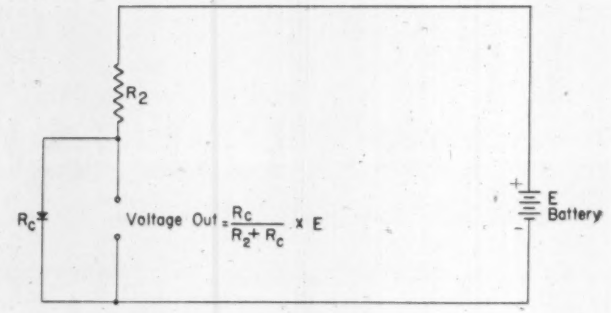


Fig. 3-4. Electrical circuit of vertical line 1 when switches are in position 00; diode conducts, and only negligibly small output appears across output terminals.

pairs of wires, and two switches. A battery supplies current to the top of the matrix through resistors in each of the vertical lines.

We make immediate use of binary arithmetic in naming the switch positions on the left side of the matrix. We say that when a switch is in up position it is in 0 position. When a switch is down it is said to be in 1 position.

Note that there are four and only four possible combinations of switches—00, 01, 10, and 11. These four combinations can represent the input number 0, 1, 2, and 3 (decimal numbers). In Fig. 3-2 the switches have been placed in a position to read 00, or decimal 0.

Let us examine the battery current in the diode matrix. In the vertical line identified 0, the current passes through the resistor and directly down the vertical line. (It can not go through the switch because the horizontal wires are insulated from the vertical wires.) Neither diode can conduct because the switches are in the 0 position. The circuit with line 0 is as shown in Fig. 3-3; the voltage appears at output 0.

Now examine line 1. The battery current passes through resistor R2 and then through diode *c* through the switch to ground. The voltage available at output 1 is that across the diode, as shown in Fig. 3-4 (the electrical equivalent of line 1). If the input resistor is chosen to be of high resistance compared to the forward resistance of the diode (which is very small), the voltage at output 1 is negligibly small. This was not the case in line 0 where the diodes are not grounded. Thus there is considerable voltage available on line 0; there is none on line 1.

Passing on to vertical line 2, it can be seen that diode *f* acts as a short circuit to the current in that vertical line. Similarly in vertical line 3, diodes *g* and *h* both short the current. As a result, the current passes through one and only one vertical line when the switches are in position 00. This line we shall call the 0 line.

Let us consider the top switch as the rightmost bit in the numbers 00, 01, 10 and 11. Now if we throw the top switch into 1 position, we have the binary number 01. Re-examining the diode matrix with this new switch configuration, we find that vertical line 1 now has the voltage, whereas lines 0, 2, and 3 are inactive because the current is grounded through diodes *a*, *e*, and *h* respectively. With the switches in position 01 we find that vertical line 1 is the only active line in the matrix of diodes.

Let the switches now be thrown to the position 10. This means the top switch is returned to 0 position and the bottom switch is placed in 1 position. This is the binary representation of the decimal number 2. Examining the diode matrix we find that line 0 is grounded through diode *b*, line 1 through diodes *c* and *d*, and line 3 through diode *g*. However, vertical line 2 is not grounded. Thus, line 2 is the active line corresponding to binary switch number 10. Finally, throwing the bottom switch to 1 to give binary 11, which is decimal 3, we find by tracing out the diode paths to ground that only line 3 is ungrounded and active.

Basic Advantage of Diode Matrix

Diodes are used for the interconnections because a diode conducts in only one direction; it allows current to flow from a vertical line to a horizontal, but never from a horizontal line to a vertical line. (If current could flow from horizontal to vertical, there would be considerable interaction between the various lines.) An alternate method for interconnecting lines and preventing interaction makes use of neon tubes; this is detailed in the circuitry given later. However, the point is that some method (such as diodes) must be used to prevent interaction between the several vertical lines.

With the diode matrix arranged as shown, we have succeeded in channeling a common voltage, here a battery voltage, to one of a number of discrete separate lines. This is analagous to the operation of a rotary switch in which the battery voltage is applied to a center terminal and, as the rotary switch turns from one contact to another, the voltage is applied to any one of a number of separate lines. However, a rotary switch can at best switch the signal 50 to 100 times a second. *With proper electronic control replacing the switches* we have used, this diode matrix can switch signals at the rate of over a million switchings a second.

Let us now demonstrate how this matrix performs certain logical operation by taking input premises and then arriving at the unique conclusions desired. Let us use the example of the tall, blue-eyed blonde, and first *program the premises* in binary numbers.

Representing Premises in Binary Code

The first step in programming a matrix is to represent each premise to be set into the switches as a binary number. For simplicity, let us say that a girl is either tall or not tall, either blonde or not blonde, and either blue-eyed or not blue-eyed. We now have a go/no-go situation. Arbitrarily, we will represent eye color by the rightmost bit in a 3-digit binary number (because 3 premises are required). Therefore, if a girl is blue-eyed, we will code her as 001, the binary representation for

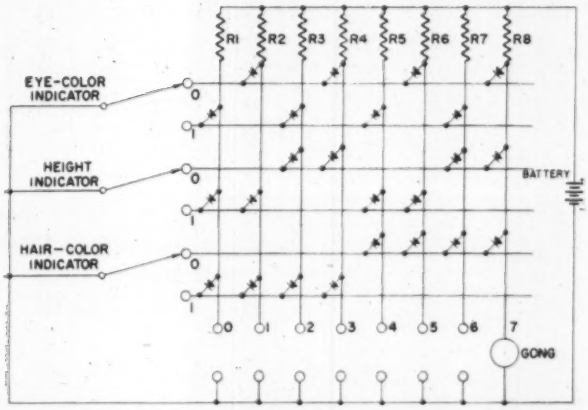


Fig. 3-5. Matrix for a 3-digit problem, such as selecting a girl who is (1) blue-eyed, (2) tall, and (3) blonde. Three switches are required because of the three premises to be programmed. Eight vertical lines are required because there are 8 possible go/no-go combinations of the 3 basic variables. With switches in the 0 position (as shown) only vertical line 0 is energized. This condition represents condition 000 (neither tall nor blonde nor blue-eyed).

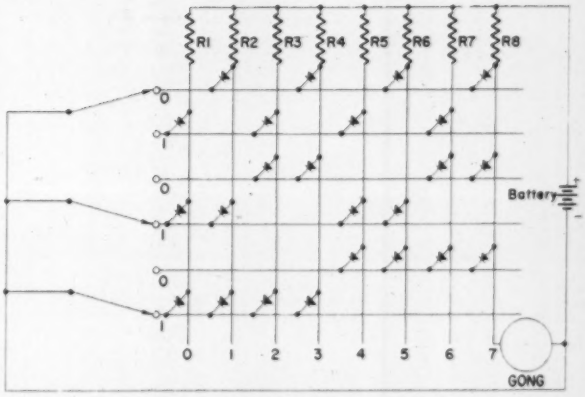


Fig. 3-6. Line 6 is energized if switches 2 and 3 are thrown to 1 position, representing binary number 110, or decimal number 6. However, all three switches must be in the 1 position before gong sounds. This would represent condition 111 (or decimal number 7), which means that a tall, blonde, blue-eyed girl has been sighted.

decimal 1; if she is not blue-eyed, she will be 000. For height, we will say that a tall girl is 010, and a girl who is not tall is 000. For hair color we will use 100 for blonde and again 000 for not blonde. We can then code any girl who passes as follows:

000 = not tall, not blonde, not blue-eyed
001 = not tall, not blonde, but has blue eyes
010 = tall, not blonde, not blue-eyed
011 = tall, not blonde, blue-eyed
111 = tall, blonde, blue-eyed

Using binary arithmetic, we see that 111 is binary for decimal number 7, the other numbers running from 0 to 7, or *eight* distinct numbers. There are eight possible combinations of premises when three separate go/no-go premises are used as above. This suggests that the matrix previously used, with only two switches and four vertical lines, is inadequate.

The fact that we have 3-digit bits suggests that we use three switches, one for each digit. As there are 8 possible combinations of the 3 basic premises, let us use eight vertical lines, one to represent each of the decimal numbers, as in Fig. 3-5.

For the first test of the matrix in Fig. 3-5, we will assign a small boy to each of the three switches. One boy throws the topmost switch to position 1 whenever a blue-eyed girl goes by; if the girl does not have blue eyes, he leaves it in 0 position. The second boy throws his switch to 1 position (representing 010) when a tall girl goes by, otherwise he leaves it in 0 position. The third boy looks only for blonde hair (representing 100) and throws the bottom switch to position 1 only when a blonde goes by. The three boys, then, act as sensing elements.

Suppose the first girl who passes is tall, has green eyes, and blonde hair. The boys would arrange the switches as follows:

000 for eye color, since eyes are not blue—first boy
010 since the girl is tall—second boy
100 since the girl has blonde hair—third boy

The number then presented to the switches is 110, which is binary for the number 6. Examining the matrix we see that only vertical line 6 is active (Fig. 3-6). In all other vertical lines, the current is grounded through one or more diodes.

Now suppose the next girl who passes has the following specifications: tall, blonde, and blue-eyed. Each of the boys will throw his switch to the 1 position, the binary switches will read 111 (which is binary for 7), and the vertical line 7 with the bell will ring; the result is the event we have been awaiting.

The premises in this example are the *eight* possible combinations of the three conditions: hair color, eye color, height. The conclusions are (1) no bell is to ring in the event seven of these eight premises occur, and (2) if the eighth event occurs with the desired specifications, the bell is to ring. The network performs this logical program for us.

Alternate Example

A more practical example of this logical programming is the case of a simple control for an airplane. Detection devices will be used for sensing elements; if the airplane is going up, one device indicates this by throwing a switch. Let this be the rightmost bit. Thus, an airplane going "up" is represented by 0001; if it is straight or level or down this device indicates 0000. A second device indicates only "down" by closing a second switch to read 0010; similarly for left, another device indicates 0100; and for right a fourth device indicates 1000.

If everything is normal, none of the transducers will produce a switch position other than 0, so the four switches will represent the binary number 0000. Let us say we wish to notify the pilot if the plane goes down and to the left. This means that the binary switch positions would present 0110, which is binary for decimal number 6. When this condition exists (as in the matrix shown in Fig. 3-6), line 6 and only line 6 is active. By examining the matrix and tracing each vertical line separately, we see that all other vertical lines are grounded through one diode or another; only vertical line 6 is active. If a bell or light is placed at the bottom of line 6, the condition we wish to notify the pilot about will be indicated.

As a simplification, suppose we eliminate all lines but the sixth, as in Fig. 3-7. As we are interested only in this line, we can save diodes and effort by eliminating

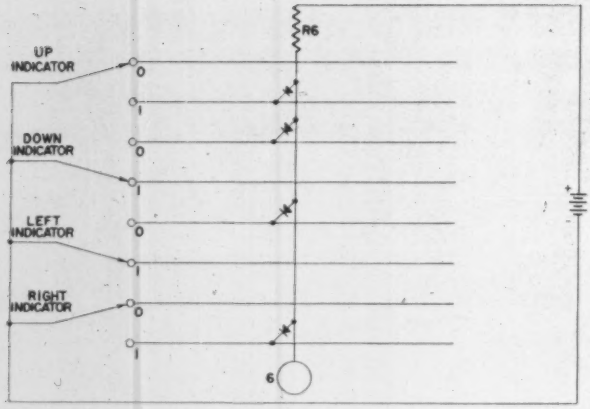


Fig. 3-7. One line can be taken from the matrix if only one condition is to monitored. In this example, line 6 of the previous matrix can be removed because we wish to ring the gong only if condition 0110 occurs, representing an airplane attitude of down and to the left. This line is called line 6 because binary 0110 is equivalent to decimal number 6.

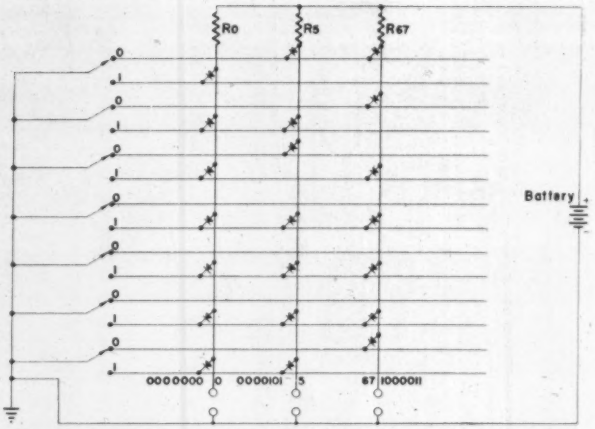


Fig. 3-8. Diode matrix for activating an output whenever condition 5, 0 or 67 occurs. Seven switches are required because the largest number (67) is represented in binary form by 1000011, which has 7 bits. Three vertical lines are used to represent the three conditions to be monitored. Diodes are placed in the matrix to connect the vertical lines to the horizontal lines at each point NOT connected to a switch when the switches are set appropriately for the condition desired.

the other lines. Note that if we extract this line from the matrix, it is inactive under every condition except the one we are interested in—condition 0110 representing "down and left." This is a practical simplification of the matrix.

Suppose now we wish also to indicate to the pilot when the plane is turning "up and left," as well as "down and left." The binary switch position for this condition is the number 0101 (binary for decimal number 5). We could extract the "five" line from the complete matrix of Fig. 3-6 and add it to the matrix in Fig. 3-7. This two-line matrix will activate on either "down and left" (vertical line marked 6) or "up and left" (vertical line 5). The pilot is thus notified if either one or the other of these conditions exists in the orientation of his airplane. We have solved a logical problem by a matrix. Note, however, that the program must be instituted at the beginning. This is true of all processes.

We could carry the automation process beyond the point indicated. The signal used to ring a bell could be used to correct the situations indicated. That is, the signal indicating down and left could be used to activate the rudder (to turn the plane right) and the elevators (to turn the plane back up again). Similarly, the up and left indicator could make correcting actions in the opposite direction by making the controls turn the airplane right and down. This is a simple automatic pilot with all the elements of a complete automation system—the sensing elements give information about the state of the airplane; the logical network performs the thinking operation or computation; finally, the matrix current controls a device which corrects the attitude of the airplane. This is a simple go/no-go automation system, for which there are innumerable applications. In later chapters, we will use this principle to control to a high degree of accuracy beyond a go/no-go system.

Extended Programming—Matrix Design

Up to this point, the positions of the diodes in the matrix have been presented as an accomplished fact, with no mention of the reasons for their locations. Let us design the matrix so that certain vertical lines represent certain specific numbers, not necessarily in numerical order.

For example, let us design a matrix which operates whenever decimal numbers 5, 0, and 67 occur (which might be the 67th pressure, or airplane attitude, or feminine characteristic, or any variable). We know that the decimal number 67 is represented by the binary 1000011, which contains seven digits. Hence we need a 7-switch matrix in which the line is activated when the first, second, and seventh switches are in position 1, all others in position 0. Such a 67 line is shown to the right in Fig. 3-8.

We have already seen (from Figs. 3-5 and 3-6) the diode configuration for the decimal numbers 5 and 0. These two lines can be added to the matrix as in Fig. 3-8 to give a system that detects the presence of condition 5, 0, or 67, as desired.

Let us review the steps required to obtain this matrix which will respond to the three (and only three) desired conditions—67, 0, and 5. First, we represented the conditions in binary code:

1000011 for 67
0000000 for 0
0000101 for 5

By observing these binary numbers we see that seven switches are required in order to represent number 67.

As we are interested in only 3 conditions, or numbers, only three vertical lines are needed. At this stage we could immediately lay out the matrix without diodes, as in Fig. 3-9.

Placing the Diodes

The diode placement to execute the logic above can be carried out simply and unambiguously. In the example we are working on, the first line is to be 5; the second 0; the third 67. To make the first line active on the binary switch position 101 (or decimal 5) we first mentally place the switches in this position, as shown in Fig. 3-10. Next we place a small checkmark, as shown, at the intersection of vertical line with each horizontal line at which there is a switch closure. All intersections *other than the ones checked* are diode connnected as

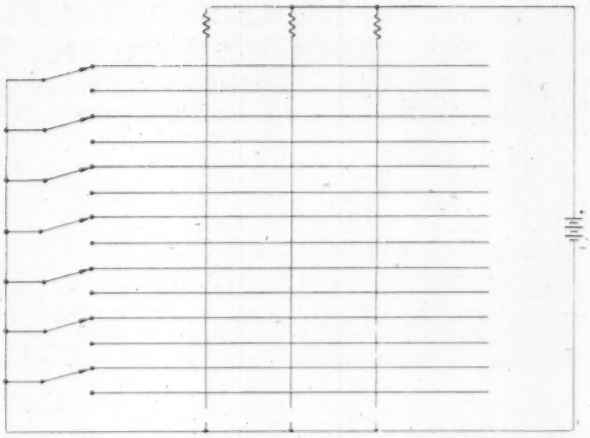


Fig. 3-9. First step in laying out matrix is deciding number of binary switches (7 in this case) and number of vertical lines (3 in this case). With seven switches there are 14 horizontal lines. This permits use of up to 128 vertical lines because there are 128 possible combinations of the 7 switches. However, only possibilities 5, 0, and 67 are to be monitored.

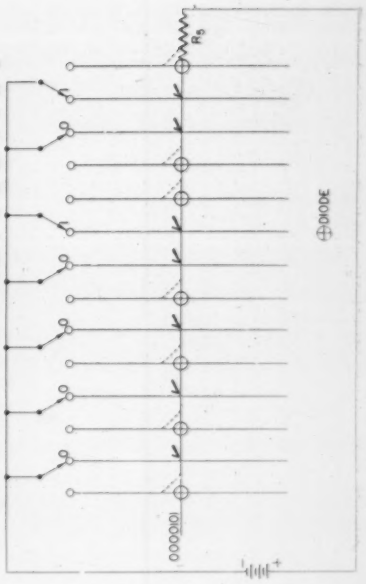


Fig. 3-10. Next step is placing diodes in matrix. Line is to be activated by number 0000101, representing condition 5. Reading upwards, the switches are placed in the 0000101 positions. All horizontal lines NOT connected to a switch are then jumpered to the vertical by diodes, as shown by dotted lines. Line will now have voltage on it when and only when the switches are in this 0000101 position, as desired..

shown by the dotted lines.

The second line is to represent the binary number 0, which is decimal 0. We place the switches in 0000000 position and repeat the operation, placing diodes at all appropriate points not connected to a switch (Fig. 3-8).

Repeating this process for 67, we arrive at the composite matrix shown in Fig. 3-8. We can check the operation of this matrix and note that if we put the switches in any of the possible 128 combinations *except* 5, 0, and 67; all lines are inactive, being grounded through one or more diodes. However, if we use any of the three numbers above, the appropriate line and *only that line* becomes the active line, as desired.

In general, in designing a binary code matrix we require as many switches as there are binary bits in the highest number to be represented. Large numbers require a considerable number of switches. However, with seven switches, as in Fig. 3-8, one hundred twenty eight (128) separate variables or conditions can be selected or monitored or controlled.

Trunking Matrix

An alternate method for using a matrix involves *trunking* the matrix. This is a technique for making a single vertical wire represent a multiplicity of diode connections, as shown in Fig. 3-11.

Note that in a conventional diode matrix (as in Fig. 3-8) each vertical line has *one* diode per switch. If two diodes per switch are connected to the vertical line as in Fig. 3-11, another switch can be located on each horizontal line to connect only the desired diodes into the matrix. Thus, by closing the appropriate switches on each horizontal line, the vertical line can represent any of many desired numbers. In Fig. 3-11, the switches are shown so that the line activates on number 10; by reversing the four diode-selecting switches, the line activates on number 01.

Fig. 3-12 shows how the 14 diode-selecting switches on a 7-bit trunked matrix are placed in order to activate the line for number 0000000; this line is then the equivalent of the conventional diode matrix shown to the right in Fig. 3-12. By changing the diode-selecting switches as shown in Fig. 3-13, the same matrix can be used to represent a different active line, in this case 0000101.

In many applications where extensive matrixes are necessary, a smaller subsidiary matrix is used to control the diode switches on the trunked matrix. Thus a single line can be activated in many different ways. The diode switches can be so controlled that they are successively connected through all possible numbers. Note that this technique converts a single-line matrix to the equivalent of a many-lined matrix.

The formal design for the diode switch closures follows the same principles developed. That is, one checks the intersections where the diodes are *absent;* all other diode-selecting connection switches must be closed to represent the number at that moment.

Trinary Matrix

Most of the work in digital automation is done in binary code, and thus the binary matrices detailed are of primary importance. However, there are occasional uses for the trinary matrix. In this instance, instead of two possible switch positions, there are three. Instead of two horizontal lines for each switch, there are three (Fig. 3-14).

We can think of the topmost position representing the trinary number 0; the second line a 1; the third a 2. These are the three numbers used in a trinary system.

Fig. 3-14 is a simple trinary matrix which counts from 0 to 8. Note that two switches in trinary can be used to represent the nine numbers 0 - 8, whereas in binary two switches can only count from 0 - 3. The advantage here is the saving in switches. This is also a three-state device instead of the go/no-go two-state device of the binary matrix, which may be of advantage.

The airplane problem discussed previously can be resolved by two switches with a trinary system, instead of the four switches used in producing the result in a binary instrument. Let us set the matrix in trinary to perform the airplane problem. The top switch will be activated by a single detecting device which can sense up, down, or straight and level, accordingly:

0 up
1 straight
2 down

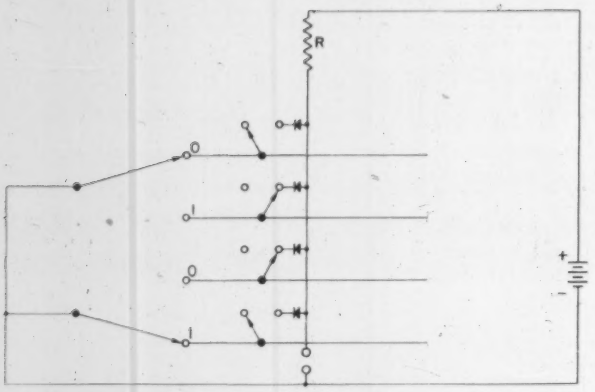


Fig. 3-11. Simple 4-count trunked matrix. A diode is connected to the vertical line above each horizontal line; and a diode-selecting switch is connected to each horizontal line. By changing the diode-selecting switches, the vertical line can represent any of the four conditions 00, 01, 10, and 11. As shown, line represents condition 10.

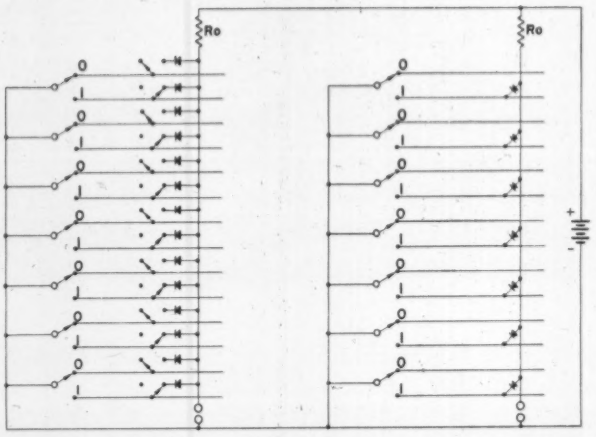


Fig. 3-12. A 7-bit trunked matrix contains 14 diode-selecting switches and 14 diodes. Any 7 of the 14 diodes are selected by the switches to make the line respond to the desired condition. Line shown responds to condition 0000000; it is exactly equivalent to the conventional 0000000 line shown to the right.

The second switch represents yaw angle or:

0 left
1 straight
2 right

Thus the condition for down and left will be the trinary number 02; up and left is the trinary number 00. To lay the diode connections into the diode matrix, we follow the same scheme as before. Let us say the first vertical line in Fig. 3-14 is to represent the condition 00. Following out previous plans, we set the switches in 00 configuration and check the intersection with the vertical line representing 00. All other intersections receive a diode connection. Similarly in line 2 we set the switches in 02 position and repeat the process for the second line. The complete composite trinary matrix is thus produced for all possible 8 conditions of airplane heading. It will activate line 00 only on the premises given, and line 02 only on the premises stated for this condition. The result is the same as that obtained using the binary matrix in the previous example. Here, as was pointed out, the detection device is now presumed to be a three-state device as compared with the two-state device previously used. Generally speaking, trinary devices are not as widely used as binary devices, the circuitry of the latter being well worked out in electronics. In simple problems, however, it may be convenient to use trinary devices, but in high-speed problems it is generally simpler to stick with the binary code and binary devices.

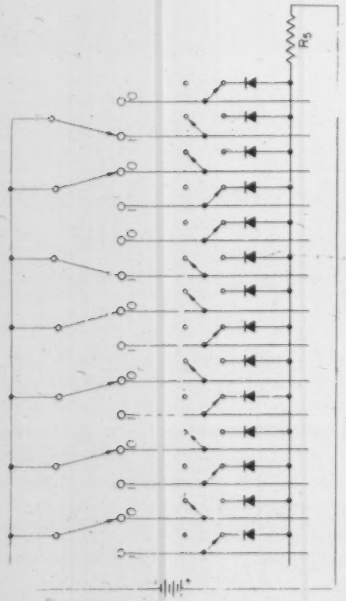


Fig. 3-13. Trunked matrix of Fig. 3-12 is changed to represent line 5 (0000101) by changing diode-selecting switches 9 and 10, and 13 and 14 (reading upwards).

Back-biasing Diodes

Up to this point, we have used switches to connect and disconnect the diodes in the problems worked. In actual high-speed operation a mechanical switch is far too slow. Switching rates up to a million per second are required, and mechanical switches cannot operate much faster than 100 a second. Accordingly, a technique has been developed which takes advantage of the fact that diodes can be back-biased.

In Fig. 3-15 a diode is shown connected to a battery in the positive direction. By using a biasing battery we can bias the diode so that conduction will take place as

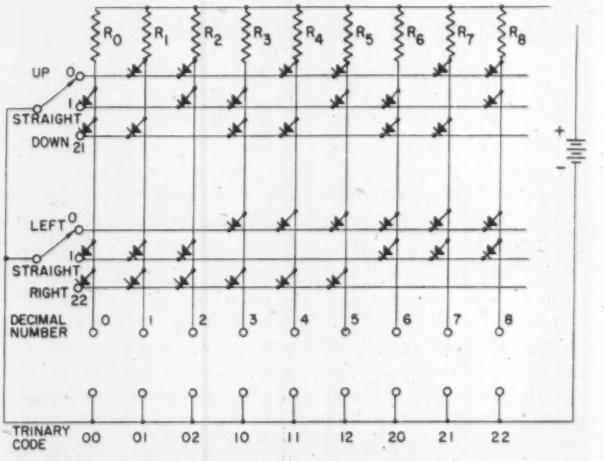


Fig. 3-14. A trinary matrix uses 3-position switches because there are 3 possible conditions for each bit. Two switches in trinary can represent nine different conditions because there are 9 possible combinations of 2 trinary switches.

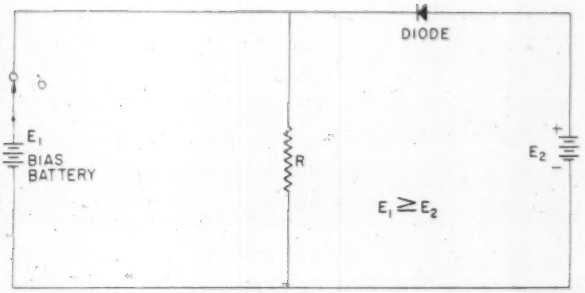


Fig. 3-15. Back biasing of diode by a bias battery prevents diode from conducting if the back bias voltage (E_1) exceeds driving voltage (E_2): Application of bias voltage is thus the same as opening the diode circuit mechanically.

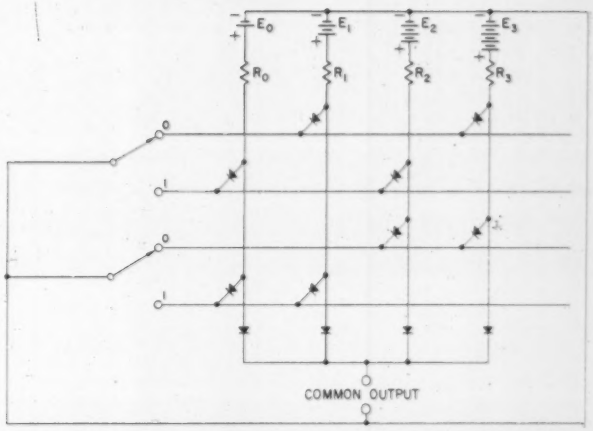


Fig. 3-17. One basic application of diode matrix is multiplexing, or time sharing. By electronic control of the switches at the left, the various inputs E_0, E_1, E_2, and E_3) are applied in turn to the common output at microsecond intervals.

long as the forward voltage does not exceed the back voltage. This amounts to disconnecting the diode by opening the switch.

Let us examine the simple binary matrix shown in Fig. 3-16. Here the binary switches on the left are replaced by a back-biasing arrangement which does the same thing as the switches previously did. The voltage divider replacing the switch back-biases the diodes, which cannot conduct. With the back-biasing shown in Fig. 3-16, we have biased the diodes to represent the switch position corresponding to 00. Thus only line 00 is active.

As the inactivity of the line depends on the dividing action of the input voltage (across the input resistor and the forward resistance of the diode), the higher the input resistance and the lower the forward resistance of the diode, the more efficiently the diode matrix will operate. A typical germanium diode has a forward resistance of 700 ohms and a back resistance of 5 megohms. Using input resistors of 100,000 ohms results in an efficient matrix which effectively makes all lines inactive except the one of interest, and eliminates interaction between the various lines owing to the high back resistance of the diode. As in all other uses of diodes, the operation of a diode depends on having a high back-to-front ratio, which means a very high resistance in the back direction and a very low resistance in the forward direction.

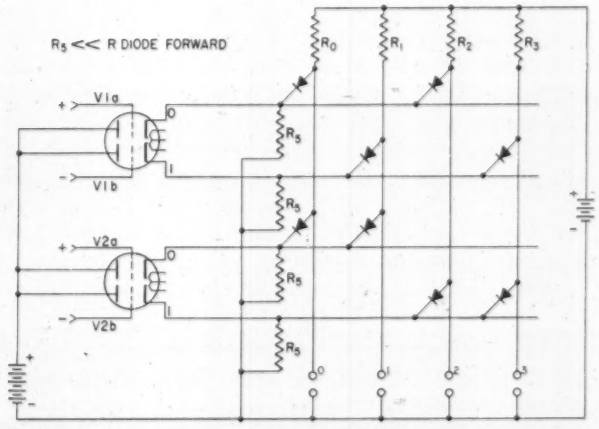


Fig 3-16. Back biasing is used here to make line 00 the active line.

Uses for the Diode Matrix

There are many uses for the diode matrix in automation systems. One use, as we have shown, is to take a single input voltage and channel it to an appropriate output. The matrix acts in this application as a distribution center, or a rotary switch. Another application of the matrix is the reverse—several input signals from different sources can be collected and allowed to pass in turn to a single input. In other words, each vertical line is fed from a separate input. The common bottom of the matrix connects to a single output line, as shown in Fig. 3-17. Here we use the matrix to activate one input at a time and eliminate all others. This principle is used in multiplexing or time-marking of a common device. For example, suppose that we wish a single Teletypewriter to receive input signals from many different cities. The lines from each city are fed to the matrix, one to each vertical line. The single matrix output of the system is connected to the Teletypewriter. By setting the binary switches we can arrange to have one and only one city read by the typewriter at a time.

These time sharing operations can be performed at rates of over a million a second. Multiplexing can be used in digital automation in the following way. Data on temperature, pressure, displacement, etc. can be fed in turn to a computer, even though all of the transducers are being read constantly. This must be done without interference from the other channels carrying information. As has been shown, this can be done with a diode matrix at high speeds; we can look at each channel for a brief interval, say 20 microseconds, then rapidly progress to the next. The use of a multiplexing device to look at several hundred inputs is not uncommon, and the speeds of commutation are so fast that negligible information is lost in the interval between "looks." The exact commutation rate can be calculated and will be discussed later under the heading of *Information Theory and its Applications to Automation*. Here, a single computer can be used to replace several hundred computers by multiplexing from channel to channel.

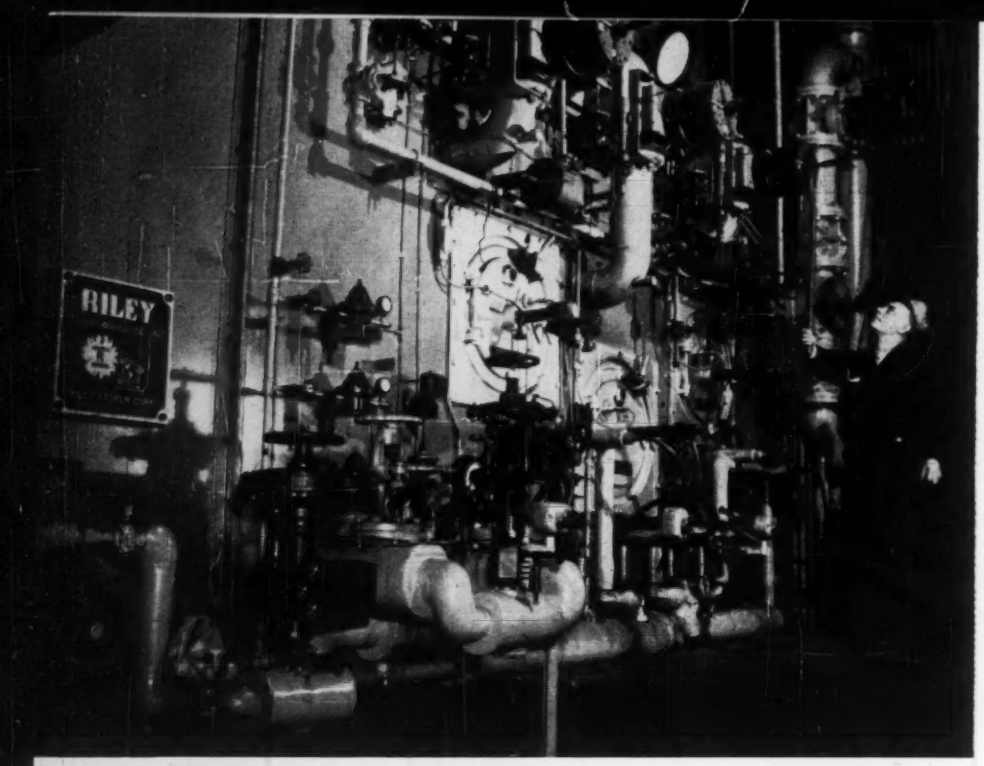


Fig. 1. Front view of one of the three Riley RX boilers shows control valves and safety interlocks. Only manual work ever required at boiler face is purge sequence before lighting pilots.

Highly Automatic

The new steam-generating facility at the Hazelwood By Product Plant of Jones & Laughlin Steel Corporation is one of the most highly automatic systems in existence—and is designed to remain under automatic control even in event of momentary power failure.

AUTOMATION in the steel industry today, particularly automatic control of combustion, is not new. However, installations where normal operations are based upon full automatic control are less common. As late as 1953, when the new gas-fired boiler house of the Hazelwood By Product Plant, Pittsburgh Works, Jones & Laughlin Steel Corporation, was being designed, there was no prototype facility in existence having all the control characteristics desired.

Today, after more than a year of successful operation, the facility is still unique in the variety and number of automatic controllers and interlocks employed. It is further noteworthy for its integrated design; the windowless building, with all equipment and appurtenances, was conceived as a whole. Its ruggedness and responsiveness were built in.

The new facility was designed also to be integrated with the existing 160,000-lb coke-breeze-fired "old boiler house" at the By Product Plant, comprising eight 20,000-lb boilers. As the general expansion of the Pittsburgh Works progressed, steam demand was increasing. The new facility was designed to more than double the older steam capacity.

Basic Design Factors

Availability of waste fuels and space limitations were major factors. Three fuels are available from the operation of the Hazelwood By Product Plant, apart from the metallurgical coke itself—coke breeze, tar, and coke-oven gas. All coke breeze produced at Hazelwood was either being burned in the "old boiler house" or otherwise used. All residual tar was also usefully consumed, although a large amount was being transported hot in specially insulated tank cars to the open-hearth furnaces. Coke-oven gas, however, was frequently flared off or bled into the atmosphere because of lack of storage; being produced irregularly and requiring cleaning, it was not considered economical to install storage facilities of the size and complexity required.

Space limitations are severe because the plant is within city limits. A spot 75 feet square within 50 feet of the old boiler house and adjoining the ammonium-sulphate plant, was the only area not already designated for production purposes.

Ultimate decision was to install three Riley RX boilers (Fig. 1) with a total nominal capacity of 180,000 lbs of steam per hour, and a peak capacity of more than 225,000

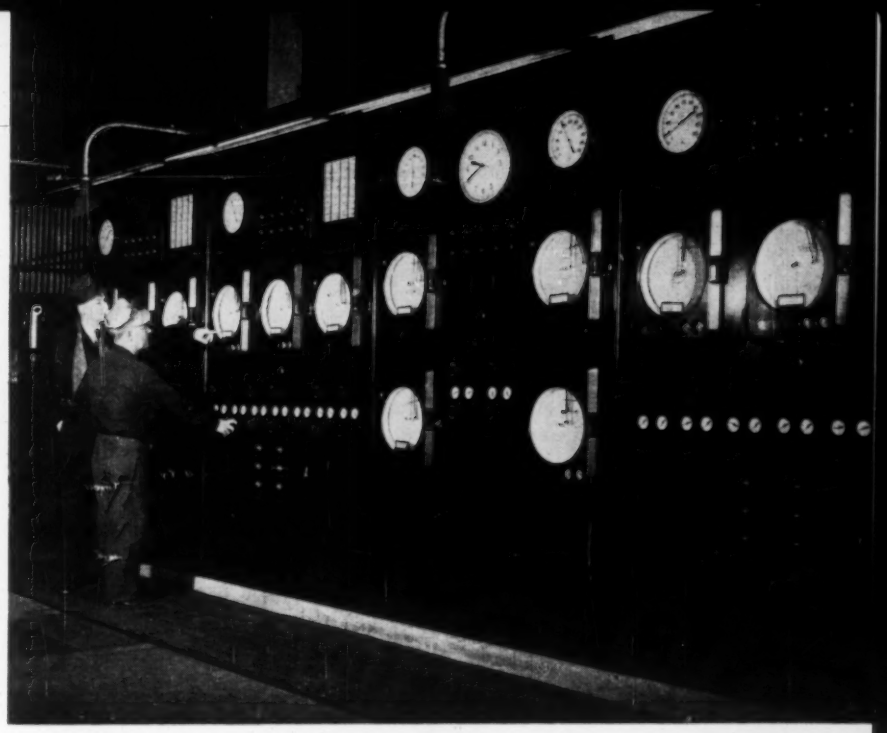


Fig. 2. Panelboard for centralized control of entire boiler house comprises four panels, one for each of the three boilers and one master panel.

STEAM GENERATION

HERBERT W. PETH
Peth & Reed, Engineers

and

JOHN A. KOTSCH
Jones and Laughlin Steel Corp.

as told to **HARRISON GILMER**

lbs. Principal fuel was to be coke-oven gas, with provision for use of residual tar as an auxiliary fuel.

The residual tar is burned just like oil, with steam atomization. One problem is liquefying the tar; at ordinary ambient temperatures (0° to 100°F) the tar is a solid. The residual tar must be kept at a temperature of 250°F if it is to flow readily in sufficient quantity through a three-inch pipe. Use of a conventional steam tracer would have involved constant maintenance expense and other difficulties, particularly because hot tar might not be required for months at a time. The solution was an all-electric system, designed with the collaboration of Fluid Systems, Inc., in which the pipe walls themselves serve as the heating element. This will be described in detail. Peabody combination oil-gas burners were selected to handle the two fuels and the separate supply of natural gas for the pilot lights.

Maximum provision was made for failure, replacement, or maintenance of components without interfering with operation of the automatic control system. For example, any two of the three burners in each boiler can maintain the maximum load. All three, however, are normally in use together. If the flame fails for any reason in any one burner, it is cut off automatically and the other two increase their use of fuel to produce the combustion rate required. Similarly, if two or three of the boilers are in use, one can be shut down automatically by reason of any one of a number of possible failures, but the remaining one or two remain in fully automatic operation.

Pneumatic Control

Pneumatic automatic controls were favored because of the desirability of the built-in dampening or smoothing effect of the air in the control lines. This avoids "hunting" or excessive cycling, and obviates additional feedbacks solely for smoothing. Where this lag is not helpful, as in the coke-oven gas pressure control described, it can be avoided by remote switching that makes possible the installation of the controller immediately adjacent to the valve operator.

All controls and instrumentation shown in Figs. 3 and 4 are pneumatic, except the Fire Eye flame scanning system. Each of the nine burners is scanned by an independent electronic Fire Eye, set to cut off all fuel to that burner (including pilot gas) in event of either flame failure or change in the character of the flame which

would indicate improper combustion. Electrical interlocks (not shown on the diagram) operate in conjunction with the Fire Eye mechanism to shut off the fuel to all three burners in a given boiler in the event of failure of feedwater, forced draft, or induced draft.

The Basic Control

Basic information for the operation of the combustion control system comes from the steam header (Fig. 3), which is fed by both the old and the new boiler houses. Any variation in pressure from a predetermined control point generates a demand signal which increases or decreases the flow of air provided by the forced- and induced-draft fans, both turbine operated.

The volume of combustion air is sensed by boiler air flow taps which generate a pneumatic signal that influences all the combustion controls, as shown in Fig. 4. This delivers fuel to the burners as required to convert the air to CO_2. This system differs from conventional practice (in which air is supplied proportionally to the fuel supply) in that the fuel is proportioned to the air. The latter system has a major advantage in that air is always available for purging. In event of flame failure the purging effect is automatic for the boiler concerned.

Figs. 3 and 4 show all the basic elements in the control system. Fig. 5 shows the actual equipments represented by each block in Figs. 3 and 4.

Fuel Control System

In following the description of the fuel control (Fig. 4), note that the tar demand exists only as a function of insufficiency of coke-oven-gas supply necessary to satisfy the steam header demands. Design provides for 300-psig steam at 600° F.T.T. (Fahrenheit total temperature) from the new facility. Note also that plant gas is another auxiliary fuel supply. In an emergency, it could be burned with only minor adjustments.

Details of Air-Flow Control System

The Steam Pressure Controller (upper left in Fig. 3) is a master sender (Hagan Type "F") which generates a pneumatic signal of 60 to 0 psi. This signal, which is constant as long as the steam header pressure is at the control point, is directed to a Master Relay which sends an equivalent signal to each of the three boilers relays. Values of permanent and temporary gradient (offset) may be matched to plant load characteristics in the master relay by means of integral (reset control) elements.

Master Relay and Boiler Relays are each of the Hagan compensating type, with provision for either automatic or manual operation. Thus the entire plant may be manually operated remotely from the Master Panel; or any one of the three boilers may be operated manually from its own panel. When set to manual, the automatic incoming signal is interrupted at the transfer valve, and a signal generated by the operation of the manual knob is substituted.

The Air Flow Regulator (Fig. 3) is of the cam-loaded diaphragm type (Hagan Type "D"). It generates a pneumatic signal (30 to 0 psi) which remains constant as long as the air flow demand signal (from the Boiler Relay) is balanced by the indication of actual air flow measured by the pressure drop across the boiler. Any unbalance results in a signal transmitted to the furnace draft auxiliary relay, where it acts to start the furnace draft-regulating system in the proper direction for variations in air flow, as will be described. The same signal, however, also is transmitted through the forced-draft-turbine Manual Control Station and a solenoid valve (not shown) to the forced-draft-fan turbine-steam control valve. The manual control station is another means of operating remotely by manual control if desirable. Normally, it is set to automatic. Failure of induced draft will energize a solenoid in the safety check system, interrupting the loading signal and substituting for it a constant 30-psi air signal. This positions the forced-draft control valve at the minimum opening, slowing down the forced-draft turbine.

The Forced-Draft-Fan Turbine Steam Control Valve is of the Fisher diaphragm-operated type, equipped with a valve positioner. A signal of 0 psi positions the valve to maximum opening. A hand jack provides for local emergency positioning. A forced-draft safety check switch (not shown) closes contacts upon failure of the forced-draft fan and thus actuates both the proper annunciator light on the boiler panel and the three Fire Eye controls on the burners of that boiler, shutting off all fuel.

The Furnace (Induced) Draft Regulator is of the same type as the Air-Flow Regulator described. It receives its information from a furnace pressure tap. Variation from the control point causes a signal that returns furnace draft to the control point. The pneumatic signal from the furnace draft regulator goes directly to the Furnace Draft Relay. This is a four-chambered totalizer (Hagan Type "F") which also receives (in its No. 2 chamber) a signal from the Air-Flow Regulator. This latter signal causes an immediate and rapid variation in combustion-air flow, in advance of the regular controlling signal from the furnace pressure tap. This bias signal is gradually removed as air flow stabilizes.

The Induced-Draft-Fan Manual Control Station, and the Induced-Draft-Fan Turbine Steam Control Valve operate in the same manner as their counterparts in the forced-draft control system.

An Induced-Draft Safety Check Switch (not shown in Fig. 3) closes on failure of induced draft and actuates both the induced-draft fan-failure annunciator light on the boiler panel and the manual reset solenoid valve (previously described as being installed in the loading signal line to the forced-draft turbine steam control valve). Thus, failure of induced draft cuts down forced draft and indirectly operates the Fire Eye fuel cutoffs. When the induced draft is returned to normal the forced draft may be reset to automatic merely by resetting the solenoid valve.

Details of Fuel Control System

Fig. 4 shows the fuel control system. Basic information comes from pressure taps which indicate boiler air flow (located alongside the taps for the air flow regulator previously described). The Air-Flow Signal Transmitter (top right of Fig. 4) is a variable ratio regulator (Hagan). It generates a pneumatic signal (0 to 60 psi) proportional to the flow of combustion air as measured by the pressure drop across the boiler. This signal is transmitted directly to a Hagan Ring-Balance Fuel-Air Re-

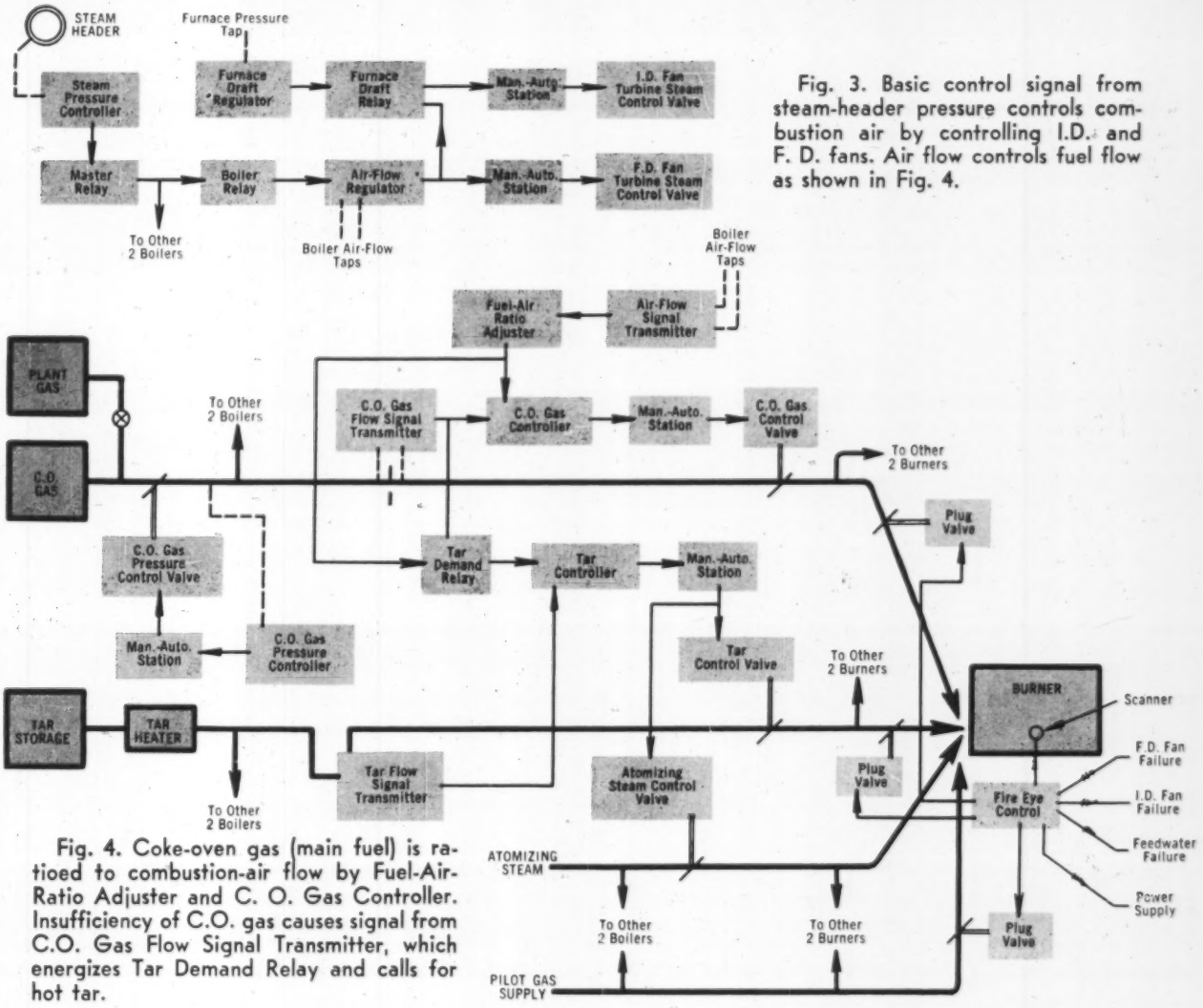


Fig. 3. Basic control signal from steam-header pressure controls combustion air by controlling I.D. and F. D. fans. Air flow controls fuel flow as shown in Fig. 4.

Fig. 4. Coke-oven gas (main fuel) is ratioed to combustion-air flow by Fuel-Air-Ratio Adjuster and C. O. Gas Controller. Insufficiency of C.O. gas causes signal from C.O. Gas Flow Signal Transmitter, which energizes Tar Demand Relay and calls for hot tar.

corder (mounted on boiler control panel) where it indicates actual air flow; and to the Fuel-Air Ratio Adjuster, where it is used as the fuel demand signal.

The Fuel-Air Ratio Adjuster is a Hagan Type "L-O" ratio relay with a panel-mounted adjusting knob, which moves the fulcrum and thus provides for changing the ratio according to requirements. The output is a pneumatic signal which bears a ratioed relation to the air flow. This control makes possible maximum combustion efficiency and holds emitted smoke well below the maximum permitted by the rigid Pittsburgh smoke-control law. The ratioed fuel-demand signal is transmitted directly both to the Coke-Oven Gas Controller and to the Tar Demand Relay.

The Coke-Oven-Gas Flow Signal Transmitter is mechanically and functionally similar to the Air Flow Signal Transmitter described previously. It generates a pneumatic signal (0 to 60 psi) proportional to the coke-oven-gas flow to the three burners of a particular boiler. This signal is transmitted directly to a Ring Balance fuel-air recorder on the boiler panel, to the Coke-Oven-Gas Controller, and to the Tar Demand Relay.

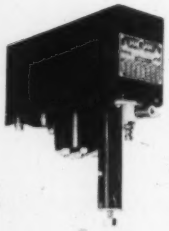
Coke-Oven-Gas Control

The Coke-Oven-Gas Controller is a Hagan Ratio Totalizer. It generates a signal (0 to 60 psi) which remains constant as long as the gas demand signal is balanced by the indication of actual gas flow. Any unbalance changes the flow to the burners. Gradient elimination (reset action) is provided by a needle valve and volume tank in a feedback line into a chamber of the controller. (Note: Feedback for reset and other details are not indicated in Fig. 4.)

The Coke-Oven-Gas Manual Control Station receives its signal from the controller and normally transmits it directly to the Coke-Oven-Gas Control-Valve Operator. In emergencies, where remote-manual operation is desired, it permits the substitution of a manually controlled signal in the manner described previously for the air flow control system. The valve operator (a Hagan Receiving Regulator) is linked mechanically to the coke-oven-gas valve operating lever. It is mounted on a floor stand and equipped with manual positioning gear. The Coke-Oven-Gas Control Valve itself is an 8" V-port butterfly with a definite position corresponding to every pneumatic signal received by its operator. As shown in Fig. 4, it controls the gas to all three burners, each of which has its own safety-check cut-off plug valve. Thus, when a single burner is cut off the same volume of gas and air continues to be burned in the remaining two burners, without manual intervention.

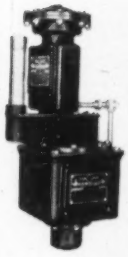
Coke-Oven-Gas Pressure Control necessary for proper functioning of the equipment already described, is pro-

STEAM PRESSURE CONTROLLER



MASTER SENDER

AIR FLOW REGULATOR

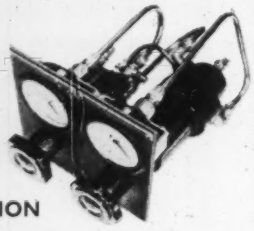


CAM LOADED DIAPHRAGM REGULATOR

MASTER RELAY

BOILER RELAY

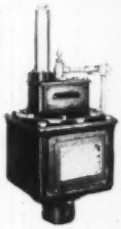
MANUAL CONTROL STATION



COMPENSATING RELAY AND MANUAL-AUTOMATIC STATION

C. O. GAS PRESSURE CONTROLLER

FURNACE DRAFT REGULATOR

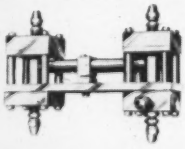


DIAPHRAGM REGULATOR

C. O. GAS CONTROLLER

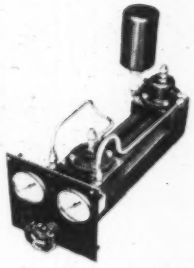
TAR CONTROLLER

TAR DEMAND RELAY



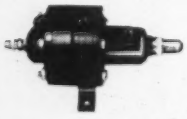
RATIO TOTALIZER

FUEL-AIR RATIO ADJUSTER



RATIO RELAY STATION

FURNACE DRAFT RELAY



TYPE 'F' TOTALIZER

AIR FLOW SIGNAL TRANSMITTER

C. O. GAS FLOW SIGNAL TRANSMITTER

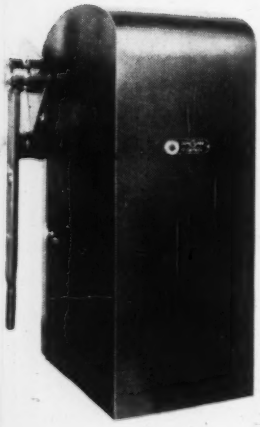
VARIABLE RATIO REGULATOR

C. O. GAS PRESSURE CONTROL VALVE

(Positioner)

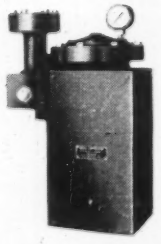
C. O. GAS CONTROL VALVE

(Positioner)



6" x 10" TORQUE TYPE PNEUMATIC POWER POSITIONER

TAR FLOW SIGNAL TRANSMITTER



FLOW SIGNAL TRANSMITTER

Fig. 5. Here are the actual equipments indicated in the blocks in the block diagrams of Figs. 3 and 4. Note that the Ratio Totalizer, for example, is used as coke-oven-gas controller, tar controller and tar demand relay. Not shown are the three types of Fisher-Governor air-operated contol valves used: *Atomizing Steam Control Valve*, Fisher Type 55T 1" 300#; *Tar Control Valve*, Fisher Type 567 1"; *I. D. Fan Turbine* and *F. D. Fan Turbine Steam Control Valves*, Fisher Type 57T 3" 300#.

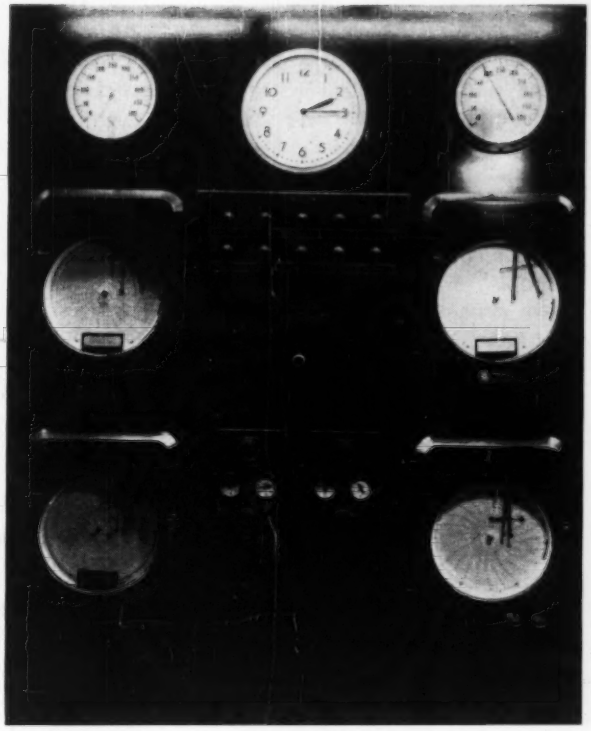


Fig. 6. Master control panel.

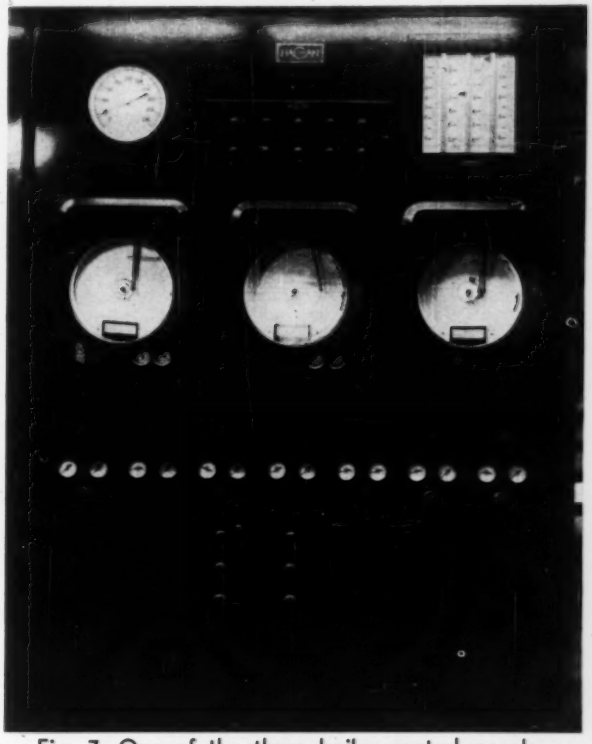


Fig. 7. One of the three boiler control panels.

vided by an independent automatic control system, shown in Fig. 4. A Ring Balance Recorder on the master panel (shown in Fig. 6) measures gas flow and gas pressure. It is equipped with a Mercoid pressure switch set to trip at 38″ W.C., which actuates the low-gas-pressure annunciator light. This system has the usual remote switching valve for remote manual operation and maximum control response.

Hot Tar Control

Residual tar produced by the by-product plant is stored in a tank maintained at a temperature above 250°F. The tank is about 900 feet away from the new facility. In order to pump this tar through a three-inch steel pipe, the temperature of both the tar and the pipe must be maintained at a minimum of 250°F., although ambient temperatures may drop to 0°F. As the tar will be required only occasionally, a conventional steam tracer was discarded as uneconomic because of costs of construction, waste of steam, and cost of maintenance. In cooperation with Fluid Systems, Inc., of New Haven, Conn., the designers worker out an electrical means of doing the job.

In this system (Fig. 8) the pipe walls represent the impedance element. Heating current is 440 v, 60 cycle, single phase, reduced to a potential of 20 to 24 v by three 15-KVA transformers, each of which serves a 300-foot section of the pipe. Cellular glass (Foamglas) covered by neoprene surrounds the pipe, serving as a water-resistant electric and heat insulator.

Electrical connections of the hot tar transmission system are shown in Fig. 8. There are 922 feet of pipe outdoors, and 130 feet indoors. Termination of the outdoor line is a steam heater, which automatically increases the temperature of tar passing through it to 300° F; at this higher temperature it can be handled in the two-inch pipe. To maintain this higher temperature in the two-inch pipe connecting the heater and the burner, a 7.5-KVA transformer supplies a low-voltage current to heat the pipe walls. Indoors, however, the insulation is three-inch-thick 85% magnesia, without the neoprene exterior protection used outdoors. Thermostats in contact with the pipe walls control the current used in each section, according to requirements. When plant operating conditions permit, no current at all is consumed.

The hot fluid tar is controlled like oil; steam is used for atomization in the Peabody burners. The Tar Demand Relay (Fig. 4), another Hagan Ratio Totalizer, generates a pneumatic signal (0 to 60 psi) proportional to fuel demand and coke-oven-gas flow. When there is insufficient coke-oven gas, a positive signal is transmitted to the Tar Controller, which provides enough hot tar, plus

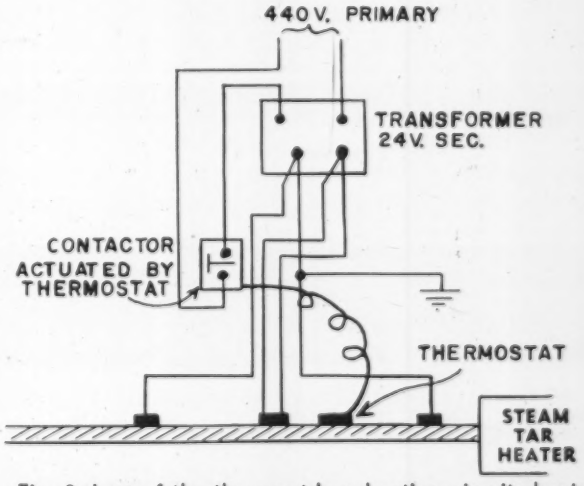


Fig. 8. Last of the three outdoor heating circuits heats about 307 feet of 3-inch hot-tar line; 15-KVA transformer causes heating current in line itself.

AUTHORS

PETH KOTSCH

Mr. John A. Kotsch (P.E.) is Combustion Engineer of the Pittsburgh Works, Jones & Laughlin Steel Corporation, and has been associated with that firm's Design Engineering Department since 1948. He was graduated from Carnegie Institute of Technology in 1941 and served in World War II.

Mr. Herbert W. Peth (P.E.) is a partner in the firm of Peth & Reed, founded in Pittsburgh in 1947. For three years prior to that date he was associated with George S. Richardson, Consulting Engineer, and for twenty years previously with the John F. Casey Co., engaged in heavy construction work. Mr. Peth graduated from Carnegie Institute of Technology in 1923. He is a member of the American Society of Civil Engineers and of the Engineers' Society of Western Pennsylvania.

The two authors worked together in the design of the facility described in the article as the chief representatives of the client, Jones & Laughlin, and the consulting engineers, Peth & Reed.

atomizing steam, to maintain the boiler load. The Tar Controller receives its feedback information from a Tar Flow Signal Transmitter.

The system uses standard equipments for continuous blowdown with maximum heat recovery, air puff soot blowers, feedwater conditioning, and the feedwater pump system. From the inception the design team felt strongly that a facility which in itself was an emergency facility to augment or replace an existing steam supply should be as truly automatic as possible. Specifically, it should incorporate maximum safeguards against avoidable shutdowns which would defeat the purpose of the installation. To this end they incorporated a standby mechanical feedwater control, a dual feedwater pump system (two turbine-driven pumps, one electric; any one of the three can carry the full load), and a looped steam supply (an auxiliary header permits continuous operation of all turbines regardless of maintenance work on the main steam header).

The many safety checks and interlocks make it possible for one man (of the normal two man crew) to continue operation by himself if the other man is not immediately available—despite the many combinations of mishaps that can occasionally occur simultaneously.

Other Safeguards

Electric power failure, by itself, does not stop steam generation. This is an unusual feature. A drop in the voltage of the plant power supply of a magnitude sufficient to affect the Fire Eye releases a spring-loaded solenoid. This in turn cuts off operating air to the three operators of shut-off plug valves installed in the fuel lines to each burner. These plug valves remain in the full-open position, and the fuel supply continues to be regulated by the automatic control system, but temporarily without the protection of the Fire Eye.

Failure of almost any component is evidenced by an annunciator light on the respective control panel (Fig. 2). Flame failure or power failure causes an audible alarm (horn) which cannot be silenced until all power-failure solenoids have been reset manually (one for each burner suffering the failure) and complete Fire Eye control restored. Both the annunciator lights and the horn, with other key electric interlocks, are powered by dc, independent of the regular plant power supply. In the act of restoring each Fire Eye Control the operator becomes aware of any individual burner or boiler which may have developed trouble. The offending component is cut out of the system temporarily until the difficulty can be diagnosed and remedial action taken.

If any boiler has all three of its burners off for any reason, an automatic-interlocked purge cycle must be accomplished before pilots may be relighted and automatic or manual control reestablished. This is the only manual operation required from the boiler operating platform when the equipment is in service. (All other so-called "manual" operation is actually by remote control from the four panelboards shown in Fig. 2). The purge interlock system mentioned is similar to one shown on page 981 of the June, 1955 issue of *Instruments and Automation*.

Feedwater Control

A simple two-element feedwater control system (steam flow and drum water level) is used. In each boiler, a pneumatic signal generated by a steam flowmeter is transmitted to a relay where it is used as the primary feedwater demand signal. A secondary signal is transmitted to the same relay by a drum water level controller. Any variation of drum level results in changing the signal sent out by the relay to the degree necessary to restore the desired drum level.

Air Supply

Air supply for all pneumatic controls is specially filtered plant air normally available at 70 to 90 psi. When the pressure falls below 70 psi an auxiliary tank supply fed by an automatically activated electric compressor is substituted for the plant air. Control lines use air reduced to 60 psi or less, depending on the individual application.

All instrument air (including emergency supply) is cleaned and dried by Hankison "Condensifilters."

Acknowledgement

Major contributors to the design included Frank C. Lauer, Assistant Superintendent, Hazelwood By Product Plant, and Gerald E. Reid, Utility Engineer, Steam Efficiency and Combustion Department, Pittsburgh Works, J & L. The first pilot was lighted in March, 1954. No major defects have become evident.

All diagrams were supplied by Hagan Corporation; photographs by Photo Associates for Peth & Reed, and by Jones and Laughlin Steel Corporation.

Measuring By-Product Yield of COKE OVENS

Determination of the operating efficiency of a coke-oven battery is vital to the oven design, construction, operation, and decision to rebuild. This article reports on 3 years' work on batteries at Sparrows Point, Johnstown, Lackawanna, Bethlehem and Steelton. Primary problem is measurement of the foul gas from the battery.

F. R. PULLEN
Bethlehem Steel Company

EVERY operator of coke ovens has wanted at some time or other to rate the by-product performance of each individual battery of his coke ovens. This is not an easy problem because in most integrated steel plants several coke-oven batteries operate in parallel, and feed their gas stream into a common by-product plant. It is relatively easy to determine the over-all by-product production of the batteries; however, the parallel operation of a number of batteries makes determination of individual battery performance quite difficult.

All batteries, particularly the newer ones, are equipped with underfiring-gas meters, waste-gas temperature recorders, and other indicating and recording instruments which aid in the operation of the battery of ovens. They also permit the operator to study the operating performance of the battery from the firing side.

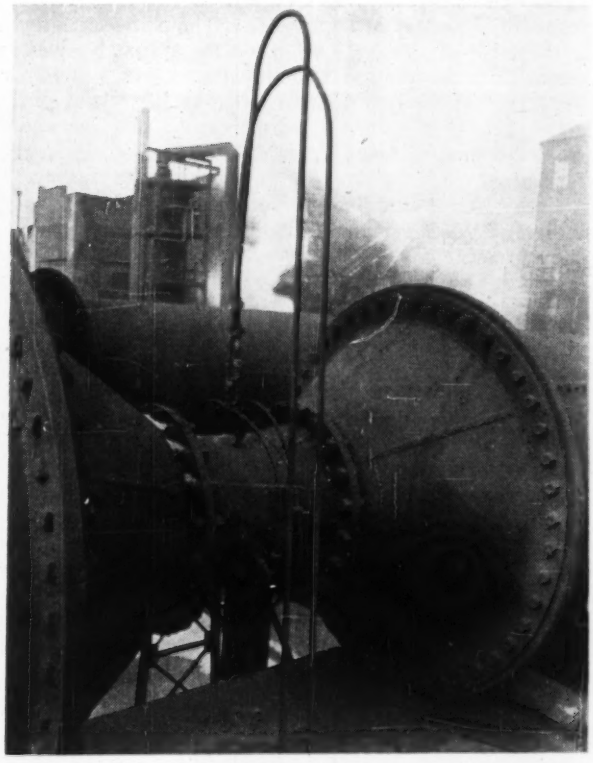


Fig. 1. Foul gas from No. 17 Battery at Johnstown was measured with this flow tube in the suction main, ahead of the primary cooler.

When Should a Battery be Rebuilt?

A coke-oven battery, like the "One Hoss Shay," will continue to operate and produce coke until practically in a state of collapse. In well-worn batteries there is some loss of coke due to the loss of individual ovens whose walls have collapsed or have become too irregular to permit pushing, but breeze production may increase due to rough, irregular oven walls. At one installation, recently shut down, the underfiring fuel could be shut off for extended periods of time; leakage through the battery walls, under proper draft conditions, was sufficient to maintain battery temperature with little or no underfiring fuel. Other batteries have been taken out of service with only a negligible loss of coke-oven gas or other by-products being registered. Such operations are obviously not economical, yet, because of the ability to produce coke, even at high cost, the batteries were operated long after they should have been shut down for rebuilding.

The reasons for this are (1) rebuilding of a coke-oven battery involves a major expenditure and requires from 10 to 14 months, (2) other sources of coke for the blast furnaces must be found while the battery is being rebuilt, and (3) it may be necessary to purchase other fuels to replace the coke-oven gas and tar being produced by the battery of ovens and being used in the plant's steel-producing and reheating furnaces. All of these costs, when added to the actual cost of rebuilding the battery, add up to a formidable figure.

As a coke-oven battery is so inconsiderate as to keep producing coke to the bitter end, the justification for a battery rebuild must be found in (1) reduction in operating and maintenance costs, (2) reduction in operating labor, and (3) increase in by-product recovery. The first two items are relatively simple to evaluate; the third is more complicated. Although the operator of a single-battery plant is able to compare coke production and by-product yields directly, most operators find themselves with a number of batteries, all pouring their by-product stream into a single by-product recovery plant. By-product yields may drop so slowly as to be almost unnoticeable. Even then it would be difficult to determine which battery was the cause of the loss of by-products.

Presented at Conference on Instrumentation for the Iron & Steel Industry, Pittsburgh, 1955.

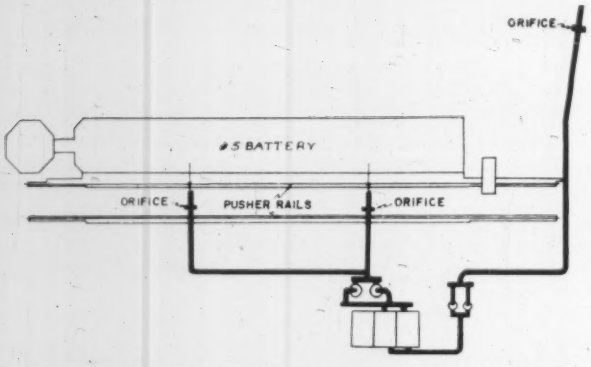


Fig. 2. Gas-metering system on No. 5 Battery at Bethlehem uses segmental orifice plates in cross-over mains for foul-gas measurement, and another segmental orifice for measurement of the clean gas after the by-product plant. This permitted comparison data.

Measuring the By-Product Yield of a Single Battery

In an effort to determine the by-product yield from one coke-oven battery, a program was set up to determine the yield of a single battery of coke ovens over a period of time. It was necessary to find a battery which discharged into a suction main independent from other batteries. Several such batteries were found—the No. 17 Battery at Johnstown, No. 7 Battery at Lackawanna, No. 5 Battery at Bethlehem, and No. 9 Battery at Sparrows Point.

Work at Sparrows Point

The first attempt to measure the foul gas from a battery was made at Sparrows Point in 1951. A pitot-venturi element was first used for flow measurement. It rapidly became evident that this primary element was not applicable because the throat and the impulse taps would plug up in less than 24 hours. Repeated attempts to use the pitot-venturi element all failed and the equipment was discarded.

The problem was discussed with representatives of a number of instrument manufacturers. This led to the installation of a permanently located flow tube in the suction main of No. 17 Battery, then being rebuilt at Johnstown. This was installed before September, 1952, when the battery was lighted.

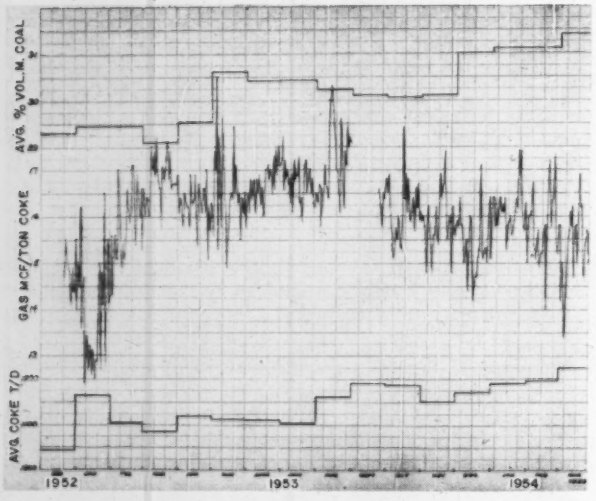


Fig. 3. Jagged curve is plot of daily gas production (cu-ft per ton-coke) as measured by foul-gas meter at No. 7 Battery at Lackawanna. Percent volatile matter is curve at top; average tons of coke produced per day is shown at bottom. Curve includes 17 months of operation.

TABLE 1. FOUL GAS MEASUREMENT, #7 BATTERY AT LACKAWANNA

Month-Year	No. of days Recorded	C.F. Gas per N.T. Coke Calculated	C.F. Gas per N.T. Coke Metered	Per Cent Difference
Dec. '52	12	14,820	14,770	— 0.34
Jan. '53	31	14,870	13,910	— 6.46
Feb.	28	14,720	15,800	+ 7.34
Mar.	31	14,950	16,830	+12.57
Apr.	30	14,070	16,240	+15.42
May	31	14,140	16,530	+16.90
June	30	14,940	16,780	+12.31
July	31	14,880	16,690	+12.16
Aug.	31	14,930	17,260	+15.61
Sept.	8	15,390	16,030	+ 4.16
Oct.	31	15,530	16,100	+ 3.67
Nov.	30	15,690	16,410	+ 4.59
Dec.	31	14,600	15,410	+ 5.54
Jan. '54	31	14,620	16,020	+ 9.57
Feb.	28	14,400	15,780	+ 9.58
Mar.	31	14,710	15,340	+ 4.28
Apr.	30	14,650	16,130	+10.10
May	31	15,500	16,140	+ 4.13

Work at Johnstown and Lackawanna

Fig. 1 shows the flow tube in the suction main just prior to the gas entering the primary cooler. A drain pot immediately ahead of the flow tube removes all liquor from the bottom of the line so that only gas and suspended liquid droplets would be carried through the flow tube.

Almost simultaneously with this installation, a segmental orifice plate was installed in the suction main from No. 7 Battery at Lackawanna. The orifice was made in the form of an open spectacle plate so that it could be removed for inspection periodically. In this installation the liquor in the line was permitted to flow through the plate. The area occupied by the liquor was subtracted from the total orifice area to determine the true orifice ratio.

Both of these installations were made on batteries with individual suction mains extending as far as the primary cooler inlet.

Work at Bethlehem

Installation of No. 5 Battery at Bethlehem was being planned at that time. As this battery was to be installed with a complete by-product plant, an opportunity was at last afforded to work with a battery where it would be possible to measure the foul gas from the battery as well as the clean product after the by-product plant. However, in this case the only available location for insertion of primary flow elements was in the cross-over mains. It was decided to install segmental orifice plates in each of the cross-over mains.

This battery began operation in November, 1953. Fig. 2 shows the location of the foul-gas and clean-gas measuring orifices in this installation.

Results

The results obtained from these three installations are interesting and encouraging. The flow tube at Johnstown and the segmental orifice at Lackawanna have been in

TABLE 2. FOUL GAS MEASUREMENT, #5 BATTERY, BETHLEHEM PLANT

Date	Ovens Pushed	Total Flow Cross-Overs	Total Gas Flow After Detarrers	% Error
3-2-54	69	25,132,440	13,094,400	54.6
3-3-54	69	24,792,936	13,200,000	57.3
3-4-54	69	24,274,560	12,540,000	53.4
3-5-54	69	24,226,200	12,592,800	54.5
3-6-54	69	24,366,096	12,672,000	54.6
3-7-54	69	25,440,128	13,220,000	55.1
3-8-54	69	25,012,776	13,015,200	54.7
3-9-54	69	25,664,520	13,323,000	54.4

operation for more than two years. Maintenance has been negligible, except for plugged impulse taps and lines. Data from each installation have been plotted over a period of months. Fig. 3 shows a plot of daily gas production expressed in cubic feet per ton of coke as measured by the foul gas meter at No. 7 Battery at Lackawanna. The average tons of coke produced per day and the percent volatile matter are also recorded by months. Table 1 is a tabulation of the average monthly gas production as measured and calculated. All batteries were operating at the same coking rate during the period of their trial run. The monthly percentage error is tabulated in the column at the right. We have not been able to explain satisfactorily the low yields metered in January, 1953. The average error between metered flow and calculated flow was 8.2%.

Data from the segmental orifices installed in the cross-over mains on the No. 5 Battery at Bethlehem are more limited. Table 2 is a tabulation of the total flow in the cross-over mains, and the clean gas flow from the plant, all expressed in cubic feet per day. The percent error is also tabulated. In calculating the orifice for this installation, all variables except one could be assumed with reasonable accuracy. The unknown was the specific gravity of the flowing medium. The gas at the point of measurement contained droplets of liquid suspended in the gas stream, which affect the specific gravity of the gas being measured. However, note that the error, though large, was relatively constant. Table 2 shows the results of 8 days. The average error for 19 recorded days was 53.3%.

The average specific gravity was found later to be approximately 0.70. A value of 0.50 was used in the original orifice calculation. Correction for this difference would reduce the average error considerably.

Use of Venturi Nozzle at Steelton

When No. 1 Battery at Steelton was shut down and rebuilt, the piping arrangement was such that it was impossible to install an orifice plate either in the cross-over mains or in the suction main. A streamlined-type venturi nozzle (Fig. 4) was selected as the metering element. As the nozzle had to be installed while the line was in service, the installation was made by inserting the primary element through a 10″ gate valve into the collector main. This also provided for the removal of the nozzle at any time for inspection. A ring-balance-type flowmeter, calibrated for a maximum head of one inch of water, was used for recording and integrating the gas flow.

The venturi nozzle was put into service at 1 P.M. on March 24, 1954, and ran continuously until 12:25 A.M., March 31, 1954, at which time the battery was shut down. The results show fairly constant readings throughout the entire period. On the fourth day, however, the recorded flow began to increase; the higher readings might be caused by the build-up of tar on the nozzle.

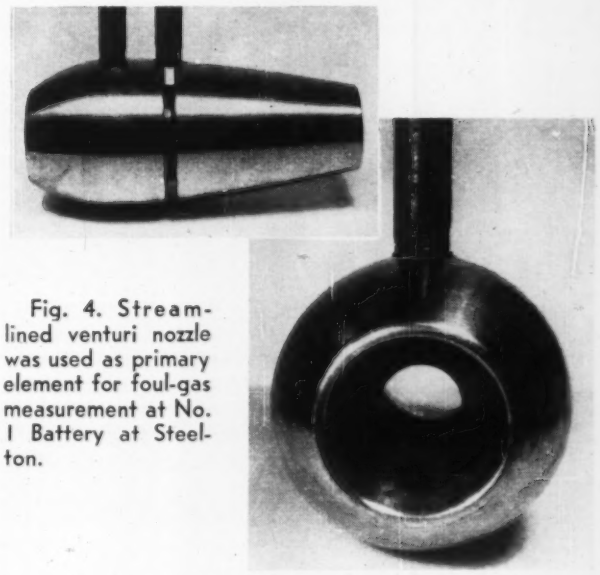


Fig. 4. Streamlined venturi nozzle was used as primary element for foul-gas measurement at No. 1 Battery at Steelton.

Inspection of the flow charts showed peaks that occurred about every twenty minutes. It was found that the peaks coincided with the time each oven was charged. This was considered to be a good indication of the sensitivity of the measuring device.

The measured flow, as determined from the calibration curves furnished by the manufacturer of the venturi nozzle, compares favorably with the calculated gas production. Allowing for possible errors in reading graphs, the flow as determined by the venturi nozzle on the first day was between 9,800,000 and 10,000,000 cubic feet per day. Using the average gas yield per ton of coke, production for this period was calculated as 9,820,000 cubic feet per day. The calculated production on the fourth day was 9,850,000 cubic feet whereas the measured flow was 10,300,000 cubic feet. This seems to indicate that the nozzle should be cleaned at least once every three days.

The results obtained throughout the test are favorable. Considering the low gas velocities, the nozzle did a fine job. Even after the nozzle was coated with tar, the readings were within 10 percent of the calculated figure. The total tar deposit was not more than 1/16″ at the heaviest point of build-up after seven days of continuous operation.

Conclusions

The following conclusions can be drawn:

1. Foul gas can be metered from the battery either in the cross-over main or the suction main. A much higher correction factor must be applied for cross-over installations because entrained liquor and tar droplets are carried in the gas stream.
2. Segmental orifices and flow tubes, when installed in suction mains, give about the same results. The segmental orifice has the advantage that it can be inspected readily, while the flow tube has the advantage of lower permanent pressure loss.
3. A flow nozzle similar to that used at Steelton can be used in the suction main. Its use in the cross-over main should also be possible. Allowance must be made for entrained liquid in the gas stream. This type of application has the advantage of lowest cost and negligible pressure drop. However, it must be cleaned more frequently than either the orifice or flow tube.

Briefs . . .

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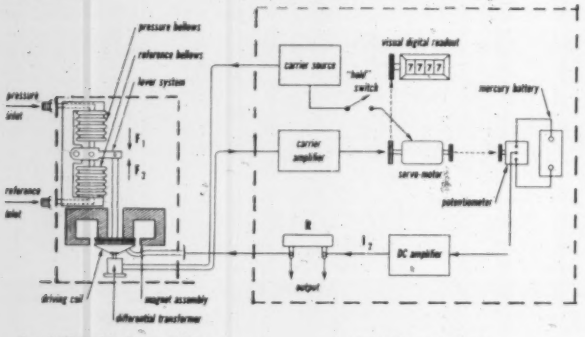

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The potentiometer provides a d-c signal for the d-c amplifier which produces current in the driving coil. The electro-dynamic force F_2 from this coil opposes force F_1, causing a movement of the linkage back to zero position. At null balance, the two forces are in equilibrium. An analog output voltage E is developed across resistor R by current I_2, which is proportional to the output force F_2. This output voltage can be measured directly or used as a control signal in conjunction with process monitoring or control equipment . . . (*From new 4-page bulletin* 1547 *Consolidated Engineering Corp.*, 300 *North Sierra Madre Villa, Pasadena* 15, *Calif.*)

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Ceramic Permanent Magnets

Indox is a new ceramic material which has many of the physical characteristics of other materials in the ceramic family, being a non-conductor, hard, brittle and much lighter in weight than magnets made of metallic alloys. These properties, together with certain superior magnetic characteristics and the availability of raw materials, expand the oppportunities for the improvement and development of products utilizing permanent magnets.

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Indox is so resistant to demagnetization that the flux can be reduced to zero and the magnet will recover and operate on a demagnetization curve essentially the same as originally. (*From new* 4-*page catalog* 15, *The Indiana Steel Products Company, Valparaiso, Indiana.*)

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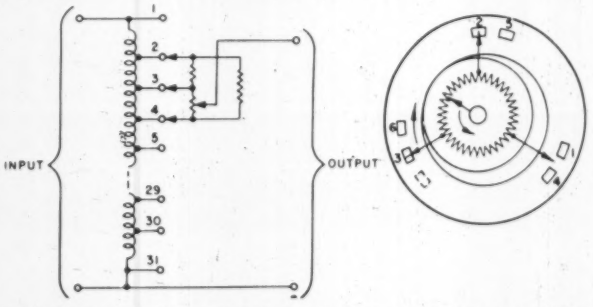
Vernistat A-C Potentiometer

The Vernistat consists of a tapped autotransformer which provides basic division of voltage into several discrete levels. Interpolation between these voltage levels is accomplished by a continuous, one-turn potentiometer, tapped portions of which are switched sequentially between taps of the autotransformer. By synchronization of the



switching with the movement of the potentiometer wiper arm, the voltage of the wiper is varied smoothly and *linearly* through the entire range of voltage provided by the autotransformer. Traversal of this range involves several revolutions of the control shaft, hence manipulation of the Vernistat is not unlike that of a multiturn potentiometer. . . . Its main characteristics are high linearity, high resolution, and low output impedance.

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For this literature circle **503** on inquiry card.

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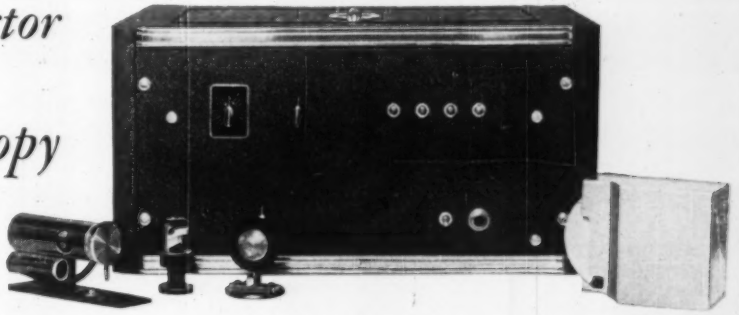

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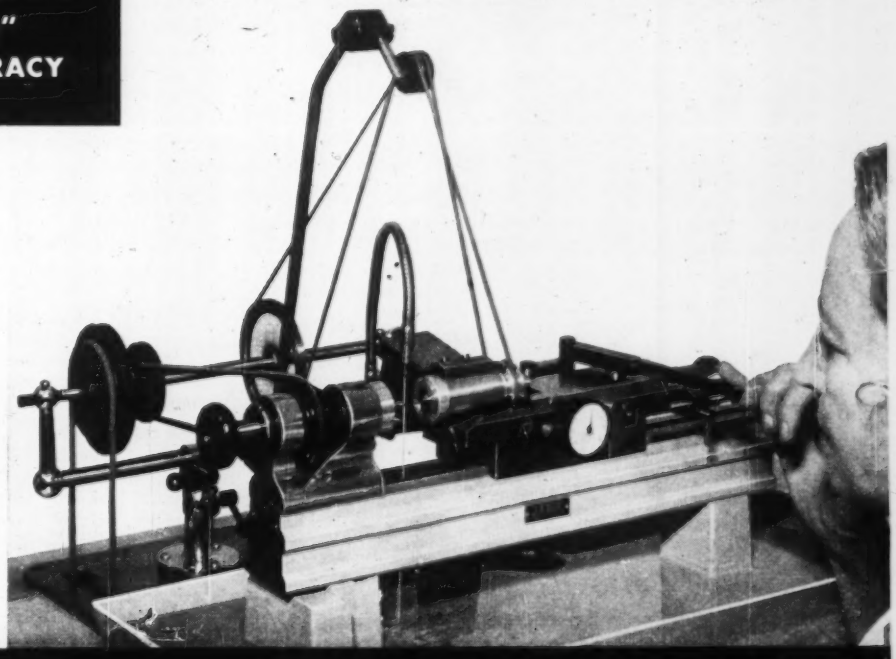

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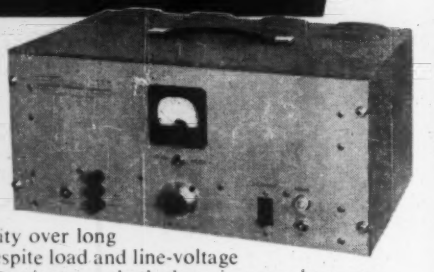

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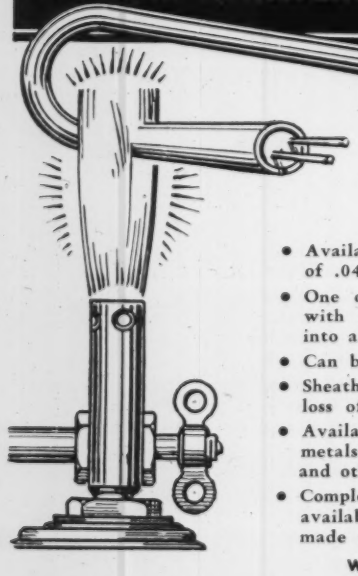

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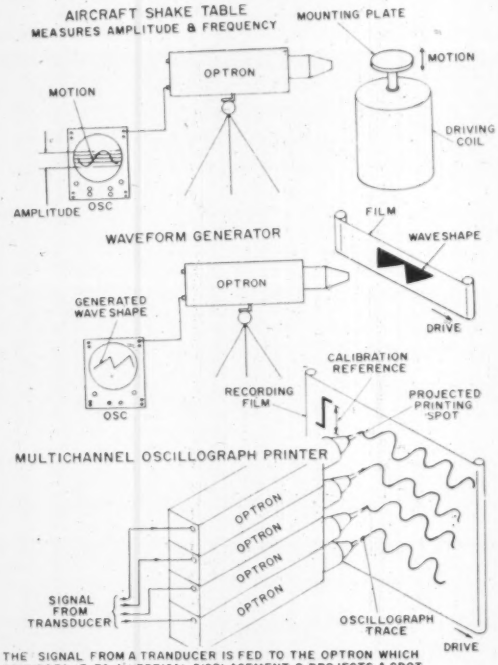

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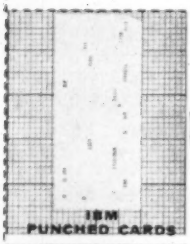

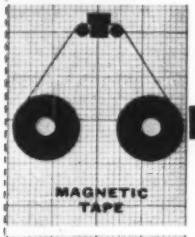

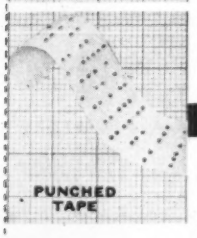

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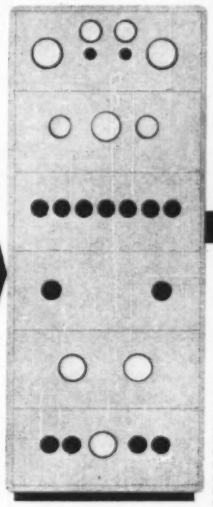

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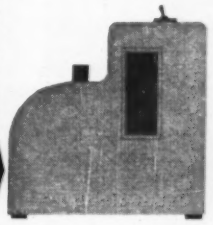

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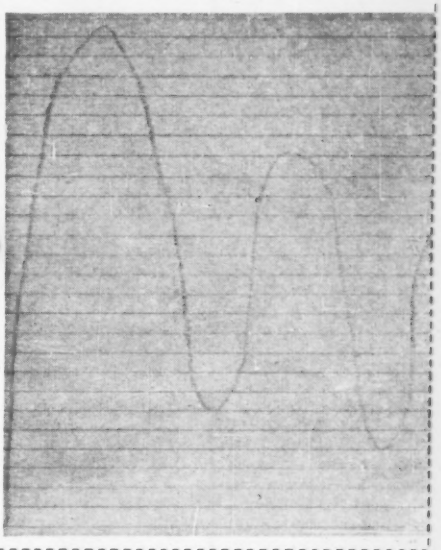

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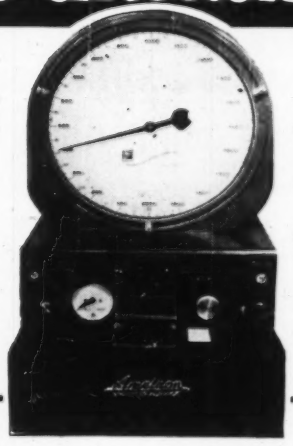

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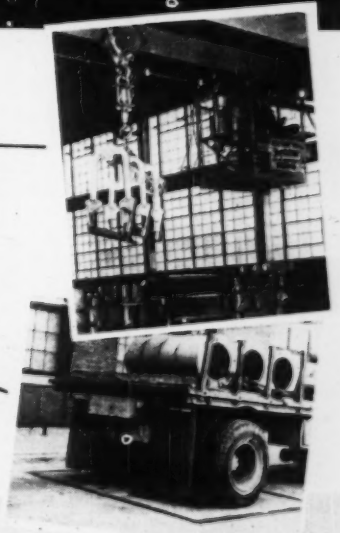

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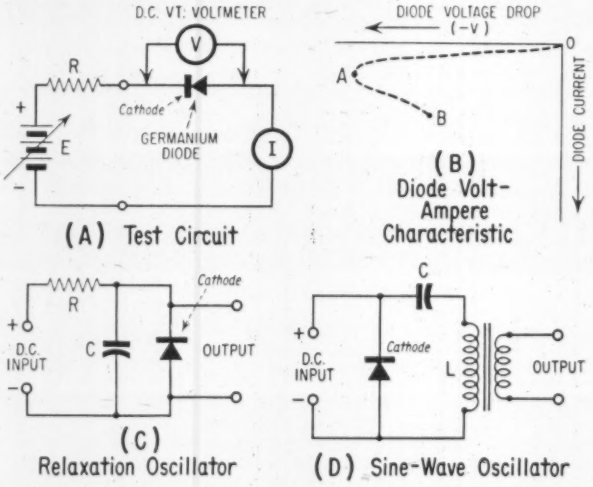

in diode tubes operated at very high frequencies (due to the fact that transient-time effects cause the dynamic plate resistance of the diode to become negative at certain of these frequencies) . . . in split-anode negative-resistance magnetron oscillator circuits . . . . in the point-contact transistor, but not in the junction type . . . the electric arc (one of the earliest two-terminal devices found to show negative resistance).

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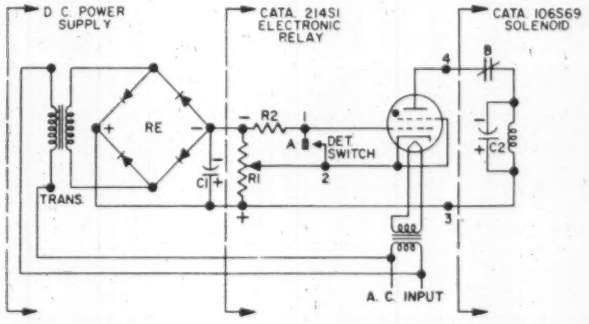
Electronic Relay

Machinery builders required a relay which would provide: (1) holding action, (2) high speed response, (3) extremely high sensitivity, (4) minimum arcing at the control contact, and (5) ability to directly control the



load operating solenoid . . . . a 2D21 hot-cathode thyratron was selected. This tube has a high control ratio (which is essentially independent of ambient temperatures over a wide range), and low grid current. Most important, when used with a D.C. supply the tube has a lock-in feature; the control grid loses control when conduction starts. Opening of the anode circuit enables the control grid to regain control . . . . When contact A is closed the tube conducts, energizing solenoid 106869. The solenoid remains energized regardless of the position of A, until the anode circuit is interrupted at B. (*From new 2-page publication* 585, *Automatic Switch Co., 391 Lakeside Avenue, Orange, N. J.*)

For this literature circle **506** on card.

New Metal Film Resistor

Probably the most common component in electronic equipment is the fixed resistor. This component, so basically simple in concept, nevertheless, is called upon to have a variety of desirable properties.

The most common type of resistor is the *carbon composition*. This type of resistor is made from a composition of powdered graphite mixed with synthetic resins and inert materials. Carbon composition resistors are normally available in 5% and 10% values. The resistor, although useful for a wide variety of applications, suffers from several disadvantages. The greatest of these is instability. At high temperature (120°C) the resistance may change as much as 20%; under severe humidity condition, the resistance may change as much as 10%. The random motion of free electrons in any conductor (including resistors) causes small potential differences to be developed across the terminals of the conductor; this thermal agitation voltage is far less than the inherent noise generated in carbon composition resistor when a direct current is passed through them. This latter noise is caused by intermittent contact between the conducting granules . . . Carbon composition resistors show varying effective resistance at high frequencies. This is due to skin effect, intergranule capacity, and inductance . . . The inductance of carbon composition resistors is small due to their relatively small size and short current paths.

The *wire wound resistor* has, for some time, been the means for achieving stable resistance values. Wire wound resistors consist of a length of resistance wire, such as

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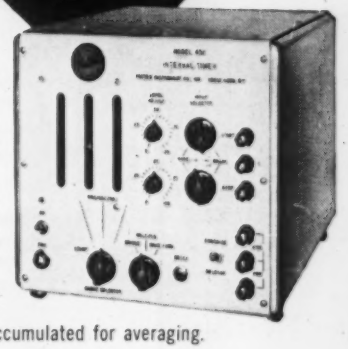
The POTTER Model 432 General Purpose Interval Timer



insures economical and precise measurement of any time interval that can be defined by pulses, contact make-or-break, or combinations of both.

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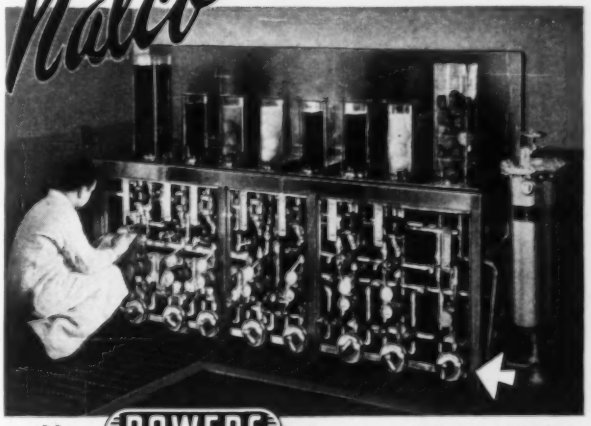

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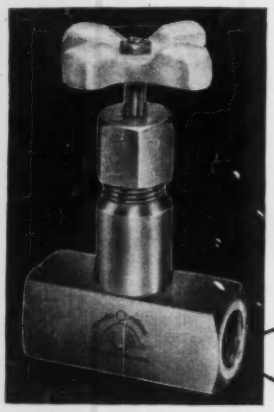

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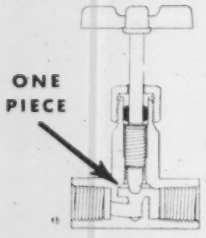

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For more information circle **104** on inquiry card.

BRIEFS—CONTINUED

manganin or nichrome, wound on an insulating core or bobbin usually of a ceramic base. Units are normally available in 1%, ½% and ¼% values. The main disadvantage of the wire wound component is its bulk and its relatively high cost.

To overcome the disadvantages of the carbon composition and wire wound types of resistors, the 1% *film resistor* has been developed. The body of the resistor generally consists of a tubular or solid material of either glass or ceramic. Deposited on and intimately bonded to the substrate is a thin resistive film connected to terminal ends . . . The resistive film is very thin. Films of pure chromium, for instance, may be only 10 to 50 atoms thick. It has been determined that as materials approach film thickness their resistivity goes up from the value established for the bulk material. The resistance of a film of a given thickness will depend upon the ratio of the length to the width. Prominent among the types of film presently being used are: carbon, boron carbon, alloys of noble metals, pure metals, such as chromium. (*From new 6-page issue Vol. 4 No. 2 of PRD Reports, Polytechnic Research & Development Co., Inc., 202 Tillary St., Brooklyn 1, N. Y.*)

For this literature circle **507** on inquiry card.

Analog-to-digital Converter

The Rea-Converter is shown by the block diagram. The four main parts of the converter are the modulator, the amplifier, the phase detector, and the summing circuits. The 4.5 megacycle oscillator supplies power to the modulator and the clock pulse generator steps the converter through the conversion from an analog input to a digital output.

The bridge modulator compares the input voltage E_x with an analog voltage received from the summing cir-

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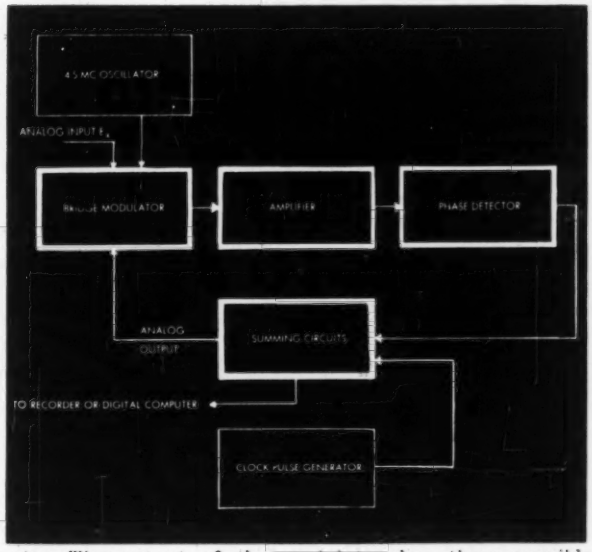

cuits. The output of the modulator has three possible forms: one when E_x is greater than the analog voltage generated by the summing circuits; one when E_x is less than the generated analog voltage and the third, or zero output form, when E_x equals the generated voltage.

The phase detector, like the modulator, can have only one of three states, corresponding to the three states of the modulator . . . The output of the phase detector is used by the summing circuits to program the analog feed back voltage.

The summing circuits consist of 13 accurate voltage sources, which are added to form a sum. The value of these sources can be chosen to fit any arbitrary scale or range required. The clock pulses turn each of these voltages on in order and each new voltage is added to the sum of the other voltages present. The voltage turned on

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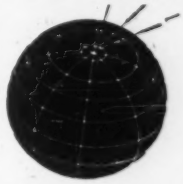

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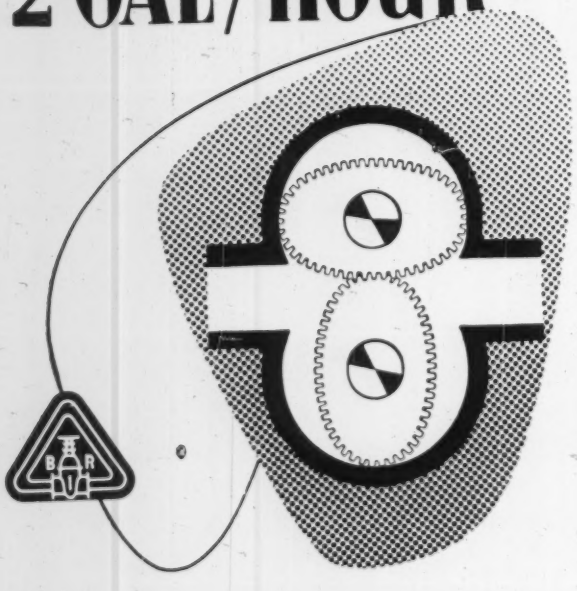

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by the first clock pulse is the largest and it is compared by the modulator with the input voltage E_x. If E_x is larger than this generated voltage, the phase detector "locks" this voltage on. If E_x is smaller, the phase detector turns this voltage off. The second clock pulse turns on the next largest voltage and adds it to the sum. The phase detector locks this voltage on if E_x is larger than this sum, or removes it if E_x is smaller . . . The following clock pulses add the remaining voltages and the phase detector either removes them or locks them in the sum. After the voltages have all been turned on and either removed or locked on by the phase detector, the voltage sum generated is equal to the input voltage E_x.

The smallest voltage source is arbitrarily assigned the number one. All other voltage sources are a whole number times larger than the smallest and are assigned that number. These ratios determine the code of the converter and can be made to match any computer code such as the binary, binary coded decimal, octal, etc. The 13 voltage sources and corresponding assigned numbers will give a ± 1000 scale when using a binary coded decimal and a higher scale, $\pm 2^{12}$, when using the binary scale. Sampling rate of standard Rea-Converter is 8000 samples/sec; higher clock frequencies give sampling rates up to 100,000/sec. (*From new 8-page brochure, J. B. Rea Co., Inc., Santa Monica, Calif.*)

For this literature circle **508** on inquiry card.

Theory of Tube Testing

Every tube tester can be placed in one of four general groups—(1) an emission type in which all elements (except cathode and heater) are tied together, and an AC voltage is applied between these elements and the cathode (Fig. 1) . . . . Group 2 differs from Group 1 in that the meter reads plate current only, rather than the combined grid, screen and plate current (Fig. 2) . . . . Group 3: here a definite signal is applied to the grid of the tube

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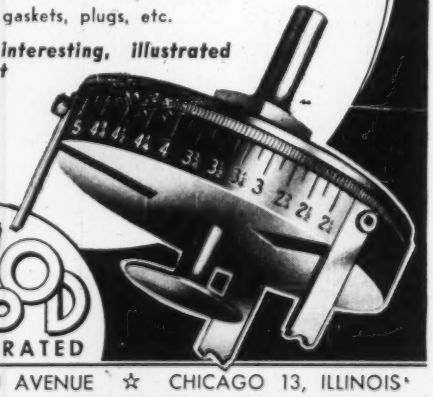

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being tested. This grid signal produces a definite change in plate current. The plate current change, in microamperes, divided by the grid signal in volts, yields a quotient which expresses in micromhos the mutual conductance of the tube .... Group 4 includes tube testers of the most precise laboratory type.

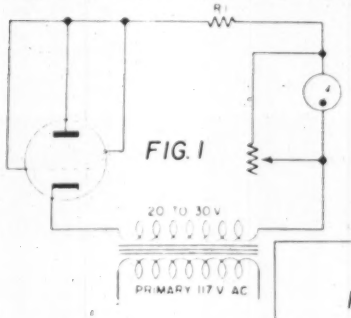

FIG. 1

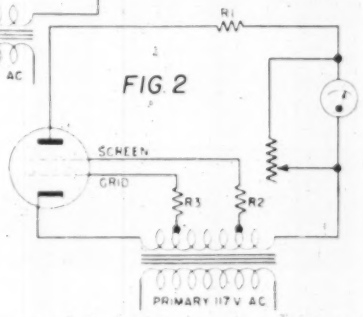

FIG. 2

The three principal characteristics of a vacuum tube are mutual conductance, amplification factor and plate resistance. To measure the amplification factor or plate resistance alone will not give a measure of the value of the tube. But mutual conductance is tied in such a way with amplification factor and plate resistance that mutual conductance is the quotient of amplification factor divided by plate resistance. See Formulas 1, 2 and 3.... It is thus seen that when we measure mutual conductance we automatically take into consideration both the other two characteristics. (*From new 20-page brochure "Dynamic Mutual Conductance Tube Testers, Theories of All Methods of Tube Testing," The Hickok Electrical Instrument Co., 10514 Dupont Ave., Cleveland 8, Ohio.*)

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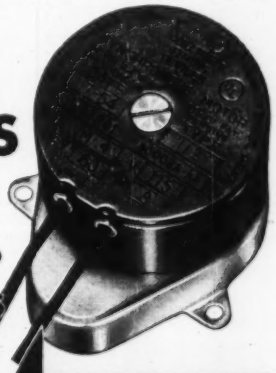

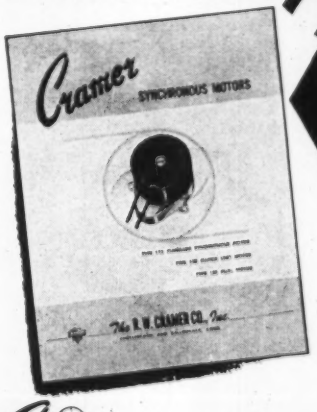

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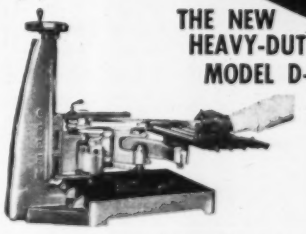

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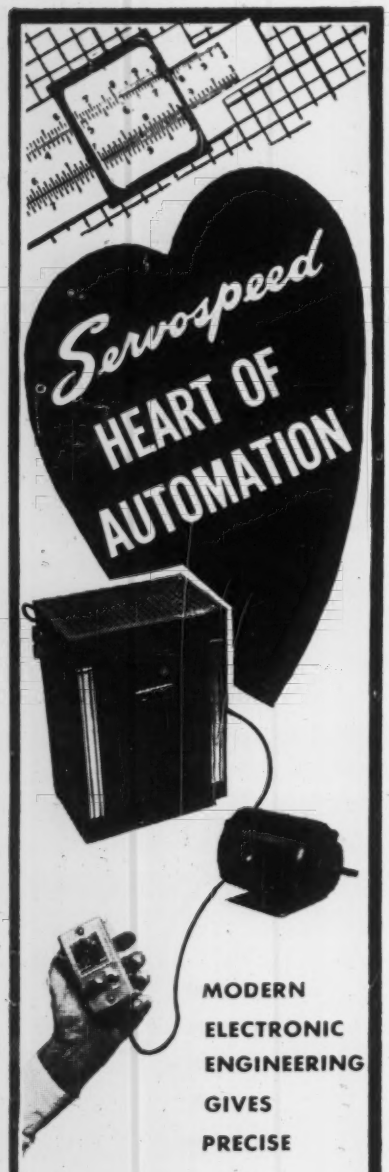

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New Literature...

For literature use the postage-free order card on page 2149

AUTOMATION

Process Instrumentation. New 28-page Bulletin GSP-901 summarizes all products and services of Hagan, Calgon, Hall Labs, and Buromin Co. Includes ring-balance instruments, transmitters, controllers, valves, conductivity meters, and chemical products.—Hagan Corp., 323 Fourth Ave., Pittsburgh 30, Pa.

Circle **510** on inquiry card.

Pump Station Control. New 16-page Bulletin PL-2 describes functions of petroleum pumping stations, types of pumping equipment, and control systems for regulation of pumping operations.—Minneapolis-Honeywell Regulator Co., Industrial Div., Phila. 44, Pa.

Circle **511** on inquiry card.

Pneumatic Transmitter. New 24-page Bulletin INS 9654 presents principles and operation of maker's pneumatic signal transmitter.—Hagan Corp., Hagan Bldg., Pittsburgh 30, Pa.

Circle **512** on inquiry card.

Analytical, Control Instruments. New 12-page General Catalog 1302B briefly describes maker's process-monitor mass spectrometers, leak detector, micromanometer, etc.—Consolidated Engineering Corp., 300 N. Sierra Madre Villa, Pasadena 15, Calif.

Circle **513** on inquiry card.

Electro-pneumatic Controllers. New 4-page Data Sheet ND46-33(106) describes maker's current-adjusting "Speedomax H" electro-pneumatic controllers.—Leeds & Northrup Co., 4934 Stenton Ave., Phila. 44, Pa.

Circle **514** on inquiry card.

Pilot Plant Control. New 2-page Data Sheet 2.10-3 describes packaged five- and fifteen-gallon pilot plants for resin experimentation which utilize maker's recording temperature control instruments.—Minneapolis-Honeywell Regulator Co., Industrial Div., Phila. 44, Pa.

Circle **515** on inquiry card.

Process Control. New 6-page Bulletin 503 describes maker's remote control systems for automatic operation of municipal water supply systems.—Taller & Cooper, Inc., 75 Front St., Brooklyn 1, N. Y.

Circle **516** on inquiry card.

Machine Tool Control. New 12-page issue of "Techniques" (Fall 1955) features article on "Binotrol" system which automatically controls Jones & Lamson's turret lathe by digital technique.—Barnes Engineering Co., 30 Commerce Rd., Stamford, Conn.

Circle **517** on inquiry card.

Machine Controls. New 12-page Catalog 65 describes maker's line of trip controls and electric two-hand clutch controls for industrial machines.—Micro Switch Div., Minneapolis-Honeywell Regulator Co., Freeport, Ill.

Circle **518** on inquiry card.

Schedule Control System. New 8-page illustrated Booklet 492 describes maker's "Produc-trol" visual control system for scheduling jobs and staff.—Wassell Organization, Inc., 108 Silvane Rd., Westport, Conn.

Circle **519** on inquiry card.

Control System Engineering. New 12-page booklet describes personnel of firm specializing in design of automatic control systems, components and computers.—Control Specialists, Inc., 115 E. Arbor Vitae, Inglewood 1, Calif.

Circle **520** on inquiry card.

VALVES

Valves. New 146-page Bulletin A-155 describes maker's "Aveco" valves for nuclear and chemical industries. Includes needle, globe, diaphragm, electric, solenoid, and relief types.—Associated Valve & Engineering Co., 1150 W. Marquette Rd., Chicago 21, Ill.

Circle **521** on inquiry card.

Power Positioners. New Bulletin TP-MF1 contains 8 specification sheets that describe maker's line of pneumatic power positioners for high-accuracy thrust and positioning applications with valves, gates, dampers.—Hagan Corp., 323 Fourth Ave., Pittsburgh, Pa.

Circle **522** on inquiry card.

Valves. New 8-page bulletin pictures and describes maker's oil, water and air valves.—Barksdale Valves, 5125 Alcoa Ave., Los Angeles 58, Calif.

Circle **523** on inquiry card.

Valves. New 4-page Bulletin 650.20 describes and illustrates maker's "Model BV" butterfly valves.—Builders-Providence, Inc., Providence 1, R. I.

Circle **524** on inquiry card.

Electro-hydraulic Actuator. New 2-page Catalog 22 describes maker's w/c electro-hydraulic actuator for valves, slides, gates, etc.—Weighing & Control Components, 64 Fulmor Ave., Hatboro, Pa.

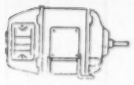
Circle **525** on inquiry card.

Thread Sealers. New 4-page Catalog 5400 describes maker's thread sealers and valve lubes.—Parker Appliance Co., 17325 Euclid Ave., Cleveland 12, Ohio.

Circle **526** on inquiry card.

INSTRUMENTS and AUTOMATION

MOTORS



Motor Speed Control. New 8-page issue of "Experimenter" (Vol. 30, No. 5) features article on "New Variac Speed Controls in 1 and 1½ hp Ratings."—General Radio Co., 275 Massachusetts Ave., Cambridge, Mass.

Circle **527** on inquiry card.

Speed Controller. New 4-page Bulletin 26 describes maker's "Varitrol" motor-speed controller.—Killeen & Son Production Engineering Co., 915 E. 59th St., Los Angeles 1, Calif.

Circle **528** on inquiry card.

Motors. New 16-page Bulletin N-100-R illustrates and describes maker's "Series 100" electric motors.—Howell Electric Motors Co., Howell, Mich.

Circle **529** on inquiry card.

TEMPERATURE

Temperature Control. New 4-page Catalog G-20 describes maker's complete line of differential-expansion temperature controllers.—Burling Instrument Co., 16 River Rd., Chatham, N. J.

Circle **530** on inquiry card.

Thermostats. New 2-page Bulletin L-6397 pictures maker's line of "Stemco" snap-action thermostats.—Stevens Mfg. Co., Inc., Mansfield, Ohio.

Circle **531** on inquiry card.

Infrared Detector Cell Accessories. New 4-page Bulletin TDS-HDCA describes maker's "Servotherm" heat detector cell and accessories for measurement and control of temperature.—Servo Corp. of America, 20-20 Jericho Turnpike, New Hyde Park, L. I., N. Y.

Circle **532** on inquiry card.

Pyrometers. New 4-page descriptive Bulletin TDS-IRPS illustrates maker's "Servotherm" infrared radiation pyrometers.—Servo Corp. of America, New Hyde Park, N. Y.

Circle **533** on inquiry card.

Infrared Night Viewer. New 2-page bulletin describes and illustrates maker's "Night Viewer" infrared equipment which "sees" by night up to 12,000 ft.—Curtiss-Wright Corp., Caldwell, N. J.

Circle **534** on inquiry card.

Infrared Detectors. New 2-page bulletin describes maker's "Opti-therm" infrared detectors for detecting infrared radiation and remote temperature measurements.—Barnes Engineering Co., 30 Commerce Rd., Stamford, Conn.

Circle **535** on inquiry card.

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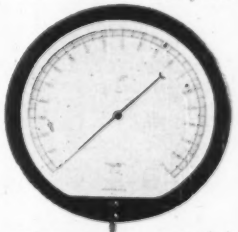

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Of ever increasing importance today, the infrared spectrum offers utilization of ideal frequencies in Process Control Instrumentation, Spectroscopy, and Military Instrumentation. To fulfill the requirements of engineers working in the near infrared region, Houston Technical Laboratories offers single crystal high purity Germanium filters and windows.

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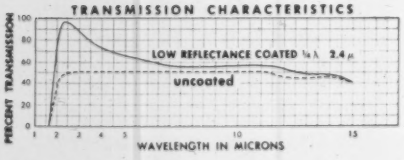

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For more information circle **117** on inquiry card.

NEW LITERATURE

Protection Tubes. New 2-page "Engineering News Letter" describes maker's Speedwell stainless-steel protection tubes for thermocouples.—Conax Corp., 7811 Sheridan Drive, Buffalo 21, N. Y.

Circle **536** on inquiry card.

PRESSURE

Pressure, Draft Gages. New 12-page Bulletin 806 describes maker's large line of small-size receivers and draft, pressure and temperature gages.—Republic Flow Meters Co., 2240 Diversey Parkway, Chicago 47, Ill.

Circle **537** on inquiry card.

Pressure Cells. New 16-page Bulletin 4306 describes uses of maker's "SR-4" fluid pressure cells in electrical measuring and control of pressure.—Baldwin-Lima-Hamilton Corp., Philadelphia 42, Pa.

Circle **538** on inquiry card.

Pressure-Sensitive Potentiometer. New 4-page bulletin describes maker's "Model 304SS" gage-pressure-type potentiometer, "Models 704 and 706" differential-pressure types with high range, and other precision pots.—Bourns Laboratories, 6135 Magnolia Ave., Riverside, Calif.

Circle **539** on inquiry card.

Digital Pressure Gage. New 2-page bulletin describes maker's "Vibrotron" digital pressure gage.—Byron Jackson Co., P. O. Box 2017, Terminal Annex, Los Angeles 54, Calif.

Circle **540** on inquiry card.

Gas Regulators. New 20-page Bulletin 1026 describes maker's pressure regulators for domestic service.—Rockwell Mfg. Co., 400 N. Lexington Ave., Pittsburgh 8, Pa.

Circle **541** on inquiry card.

Vacuum Regulator. New 2-page Bulletin 655 describes and illustrates maker's "Micro-Set" manostat for regulating and holding constant vacuum within 0.05 mm mercury pressure.—Precision Scientific Co., 3737 W. Cortland St., Chicago 47, Ill.

Circle **542** on inquiry card.

FLOW

Vane-type Flowmeters. New 2-page Bulletin F-3 describes and illustrates maker's "Models L and LP" flexible-vane-type indicating flowmeters.—Scully-Jones and Co., 1901 S. Rockwell St., Chicago 8, Ill.

Circle **543** on inquiry card.

Rotocycle Meters. New 8-page Bulletin OG 409 describes maker's line of positive-displacement "Rotocycle"

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meters for metering alcohols, brine, water, ketones, organic esters, etc.—Rockwell Mfg. Co., 400 N. Lexington Ave., Pittsburgh 8, Pa.

Circle **544** on inquiry card.

Water Meter. New 12-page Bulletin 380-K4A describes maker's "Propel-oflo" meter for metering water and other liquids.—Builders-Providence, Inc., Div. of B-I-F Industries, Inc., Providence 1, R. I.

Circle **545** on inquiry card.

PUMPS

Diaphragm Pump. New 2-page Bulletin 1201 describes maker's "Chlor-O-Feeder" diaphragm pump for feeding chemicals, sewage, etc.—B-I-F Industries, Inc., 345 Harris Ave., Providence, R. I.

Circle **546** on inquiry card.

Proportioning Pump. New 2-page Bulletin 1105.20 describes maker's "Model 1105 Adjust-O-Feeder" proportioning pump.—Proportioneers, Inc., Providence 1, R. I.

Circle **547** on inquiry card.

Displacement Pumps. New 2-page illustrated bulletin describes maker's bronze displacement pumps.—EECO Engineering Co., 12 New York Ave., Newark 1, N. J.

Circle **548** on inquiry card.

LEVEL

Level Indicator. New 4-page booklet describes maker's "Roto-Bin-Dicator" level indicator used on bulk material in bin.—Bin-Dicator Co., 13946 Kercheval Ave., Detroit 15, Mich.

Circle **549** on inquiry card.

Capacitance-operated Relay. New 2-page bulletin describes maker's "Electr-O-Probe" (Model B-06) capacitance-operated relay that acts as a liquid-level detector for foam, interface and fluid solids.—Instruments, Inc., 122 N. Madison, Tulsa 6, Okla.

Circle **550** on inquiry card.

RECORDING

Recording Systems. New 16-page illustrated Bulletin 1 describes maker's "150" oscillographic recording systems, in 1, 2, 4, 6 and 8-channel models.—Sanborn Co., 195 Massachusetts Ave., Cambridge 39, Mass.

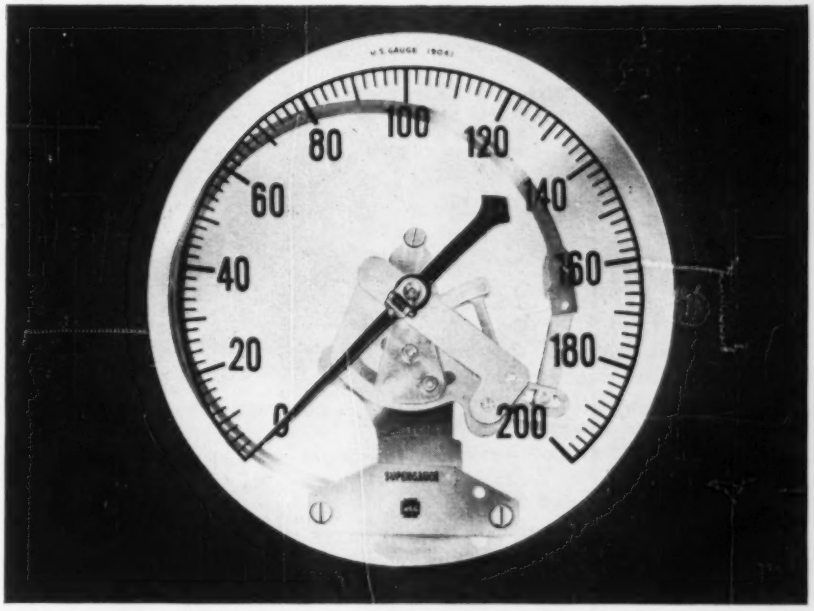
Circle **551** on inquiry card.

Oscillograph Recording Systems. New 8-page issue of "Right Angle" (Vol. 3, No. 1) describes maker's two-channel logarithmic recording system and other systems; also feature article on "Zero Suppression."—Sanborn Co., Cambridge 39, Mass.

Circle **552** on inquiry card.

Copying Machine. New 4-page bulletin describes maker's "Copease" office copying machine.—Copease Corp., 270 Park Ave., New York 17, N. Y.

Circle **553** on inquiry card.



New Supergauge Movement Extends Gauge Life; Gives Users Many Extra Benefits

In the quest for longer gauge life under severe operating conditions, one of the principal hurdles confronting instrument engineers has been the problem of gear tooth wear. Many efforts have been made to solve this problem including the use of materials other than metal.

U. S. Gauge research indicated nylon rolling on stainless steel provided the best solution if proper control of the nylon were achieved. All past experience showed that expansion of the nylon when subjected to heat and humidity changed pitch diameter causing binding and wear. This destroyed the gear rolling action, thus defeating its main advantage of assuring longer gauge life under severe operating conditions.

Using a new approach to the problem, U. S. Gauge engineers developed the new *ARC-LOC movement.

Molded nylon is bonded to the face of the stainless steel segment to maintain pitch diameter. Gear teeth are then accurately generated on the nylon face to assure perfect rolling action on the stainless steel pinion. The segment gear face is broad and all bushings or pivots are deep to assure strength and ruggedness. The result is longer gauge life under severe operating conditions.

Since nylon is applied to the arc of the sector, any tendency of the nylon to grow or shrink occurs along the periphery instead of along the radius. Thus, accurate pitch diameter is maintained and there is no wear from binding. With this design, the smooth gear rolling action between segment and pinion continues even under adverse conditions of heat and humidity.

The new U. S. Gauge ARC-LOC movement also provides several additional features of interest to the user: For easier adjustment the complete movement can be rotated about the pinion axis, positioned properly and locked from the rear. This provides the advantage of linearity adjustment without removing dial and pointer. The unique locking method also eliminates creep during locking.

The Arc-tang segment allows range adjustment without resetting of the pointer.

These added advantages mean savings in time during calibration . . . an important factor in maintenance reduction.

For complete information on the savings that are made possible by U. S. Gauge's new Supergauges and Solfrunt gauges with the new ARC-LOC movement, write for Publication 1819.

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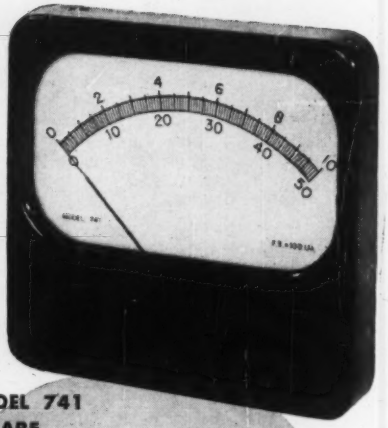

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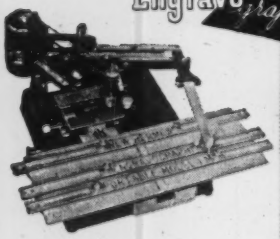

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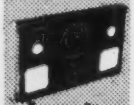

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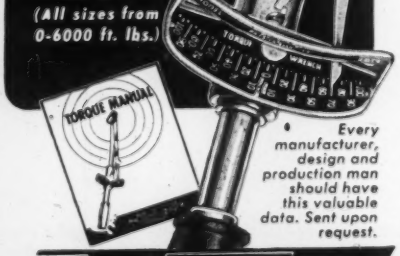

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NEW LITERATURE

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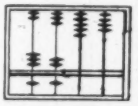


Analog Computer. New 4-page bulletin pictures and describes maker's "build-it-yourself" electronic analog computer kit.—Heath Co., 1944 Territorial Rd, Benton Harbor, Mich.

Circle **554** on inquiry card.

Data Translator. New 2-page data sheet describes maker's "Model 3154" Doppler data translator that uses digital techniques for translating Doppler data.—Potter Instrument Co., Inc., 115 Cutter Mill Rd., Great Neck, N. Y.

Circle **555** on inquiry card.

G-P Digital Computer. New 12-page Booklet A-655 describes maker's "Readix" general-purpose digital computer for scientific computation, data processing, etc.—J. B. Rea Co., 1723 Cloverfield Blvd., Santa Monica, Calif.

Circle **556** on inquiry card.

Storage Tube. New 4-page brochure describes maker's "6571" computer storage tube for binary-digital computer systems.—Radio Corp. of America, Harrison, N. J.

Circle **557** on inquiry card.

RADIOACTIVITY

Nucleonics. New 44-page brochure "The Atom in Our Hands" features article on "Unlimited Horizons in Atomic Research," and covers production of radioactive materials and their uses in medicine, industry and agriculture.—Union Carbide and Carbon Corp., 30 E. 42nd St., New York 17, N. Y.

Circle **558** on inquiry card.

Test Reactor. New 20-page Bulletin GER-1123 pictures and describes operation of maker's light-water and oil-moderated nuclear test reactor.—General Electric Apparatus Sales Div., Schenectady 5, N. Y.

Circle **559** on inquiry card.

Research Reactors. New 8-page Bulletin GEA-6326A describes four nuclear research reactors and uses—swimming pool reactor, water boiler reactor, heavy-water and nuclear test reactors.—General Electric Co., Schenectady 5, N. Y.

Circle **560** on inquiry card.

Radiation Measurement. New 20-page Catalog B describes and illustrates maker's scalers, counters, ratemeters, etc.—Technical Measurement Corp., 140-142 State St., New Haven 11, Conn.

Circle **561** on inquiry card.

Scaler. New 4-page folder RC-151 presents data on maker's "EIT" ratemeter for proportional, scintillation or geiger counting.—North American Philips Co., Inc., Mt. Vernon, N. Y.

Circle **562** on inquiry card.

Geiger Counter. New 4-page leaflet describes maker's "Model RM2NA" uranium "Orelokator" for uranium prospecting.—Radiac Co., Inc., 489 Fifth Ave., New York 17, N. Y.

Circle **563** on inquiry card.

Radioactivity Detector. New 4-page Bulletin 130-5M describes maker's "Model SC130GP" exploration scintillation counter with geiger probe attachment, remote alarm-meter attachment and other portable accessories.—Mount Sopris Instrument Corp., 1320 Pearl St., Boulder, Colo.

Circle **564** on inquiry card.

OPTICAL

ITV. New 4-page Bulletin 508 pictures and describes maker's television system for supervising plant and traffic operations.—Taller & Cooper, Inc., 75 Front St., Brooklyn 1, N. Y.

Circle **565** on inquiry card.

Precision Rotary Table. New 2-page bulletin describes maker's "Leitz" optical rotary table.—George Scherr Optical Tools, Inc., New York 12, N. Y.

Circle **566** on inquiry card.

Photometric Unit. New 6-page Bulletins 161 and 162 describes maker's automatic and manual photometric units for measuring color, gloss, reflectance and other optical properties.—Gardner Lab., Inc., Bethesda 14, Md.

Circle **567** on inquiry card.

Photoelectric Systems. New 20-page booklet describes uses of maker's "Fotolectric" equipment in industry, including use on traffic, counting, burglar alarm, combustion control, etc.—Worner Electronic Devices, Box 125, Rankin, Ill.

Circle **568** on inquiry card.

STRAIN, TORQUE

Bridge Balance. New 2-page Bulletin CEC 1560 describes and illustrates maker's "Type 8-110" 4-channel bridge balance used in coupling strain gages, etc.—Consolidated Engineering Corp., 300 N. Sierra Madre Villa, Pasadena, Calif.

Circle **569** on inquiry card.

Calibrator. New 2-page illustrated bulletin describes maker's strain-gage calibrator.—American Instrument Co., Inc., Silver Spring, Md.

Circle **570** on inquiry card.

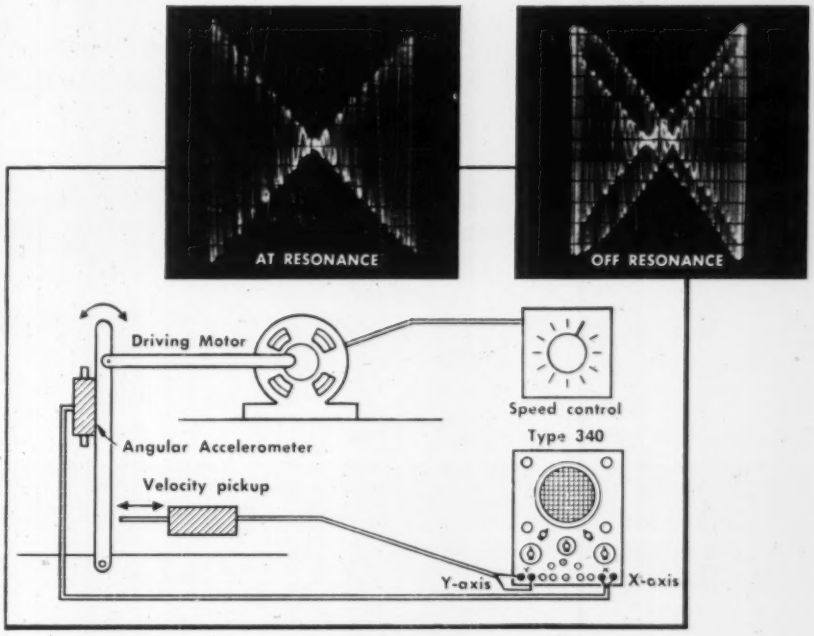
Dynamometer. New 2-page Catalog Sheet 10-B describes maker's "Model 10-B" dynamometer for measuring torque on small instruments, gear trains, servo motors, etc.—Bischof Die and Engraving Co., 1405 16th St., Racine, Wisc.

Circle **571** on inquiry card.

INSPECTION

Flaw Detector. New 2-page bulletin describes maker's "Sonometer" direct transmission, non-destructive flaw detector.—Curtiss-Wright Corp., Caldwell, N. J.

Circle **572** on inquiry card.



Identical amplifiers of the new DU MONT TYPE 340 simplify accelerometer test

A problem at the Kearfott Company, Inc. was production testing for natural frequency of an angular accelerometer very near critical damping. They chose the new Du Mont Type 340 as ideal for their measurement since it contains X- and Y-amplifiers which are identical in both phase and amplitude response from dc to 100 kc. In this test, the frequency of the driving force to the accelerometer under test is simply varied and accelerometer output applied to the Y-axis of the Type 340. A velocity pickup measures velocity of drive and its output is applied to the X-axis of the Type 340. At the natural frequency of the accelerometer, its output will be 90° out of phase with displacement or in phase with velocity. Thus, the plot of accelerometer output vs. velocity produces the hourglass waveforms shown above. At resonance, there will be no deflection at the "neck" of the hourglass. Damping has no effect on the test.

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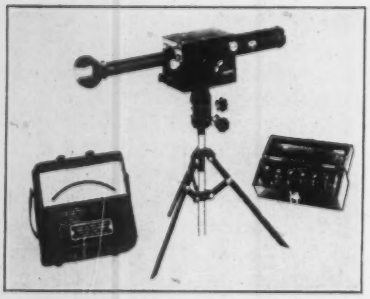
NEW! PYRO Micro-Optical PYROMETER



Sufficiently portable to be used for general plant operations, the NEW PYRO Micro-Optical Pyrometer has been developed to meet the demand not only for higher degrees of accuracy, but also greater versatility in measurement of temperatures over 700° C. (1300°F).

It measures targets less than .001" in diameter, and by means of supplementary lenses, can be adjusted for focal distances from 5 inches to infinity. Mountings on table-top and floor-type tripods are available and vernier worm gears permit extremely fine vertical and horizontal adjustments of the telescope. Wide scale, direct reading meter makes for extremely accurate reproduction of temperatures. Ask for free catalog #95.

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NEW LITERATURE

Surface-Roughness Testing. New 2-page illustrated Bulletin LT16 describes maker's equipment for automatically sorting parts according to surface roughness.—Micrometrical Mfg. Corp., 345 S. Main St., Ann Arbor, Mich.

Circle **573** on inquiry card.

Balancing Machines. New 24-page catalog describes and illustrates applications of maker's "Dy-Namic" balancing to improve machine maintenance work and production techniques. —Bear Mfg. Co., Rock Island, Ill.

Circle **574** on inquiry card.

GAGING

Surface Plates. New 68-page Technical Manual describes manufacture of "Microflat" black granite surface plates and precision inspection accessories.—Collins Microflat Co., 2326 E. 8th St., Los Angeles 21, Calif.

Circle **575** on inquiry card.

Gaging System. New 4-page illustrated Bulletin 61-209 describes maker's "Micro-Step" gaging system, comprising gage blocks, holders, etc.—DoAll Co., Des Plaines, Ill.

Circle **576** on inquiry card.

Height Gages. New 2-page Bulletin 105-10 describes and illustrates maker's micro-height gage for measuring layout and inspection work.—Griest Mfg. Co., New Haven 15, Conn.

Circle **577** on inquiry card.

LAB APPARATUS

Lab Equipment. New 12-page Catalog 55-A 35E pictures and describes maker's center and wall tables, service fixtures, storage cabinets, etc.—Metalab Equipment Co., 214 Duffy Ave., Hicksville, L. I., N. Y.

Circle **578** on inquiry card.

Plastic Lab Ware. New 10-page Catalog D-1055 pictures and describes maker's laboratory polyethylene ware. —Palo Laboratory Supplies, Inc., 81 Reade St., New York 7, N. Y.

Circle **579** on inquiry card.

Electrophoresis. New 2-page Bulletin 690A pictures and describes maker's "Ionograph" apparatus for paper-strip electrophoresis.—Precision Scientific Co., 3737 W. Cortland St., Chicago 47, Ill.

Circle **580** on inquiry card.

Lab Apparatus. New 12-page issue of "Lanco Apparatus News" (Vol. 7, No. 1) describes maker's polyethylene sink trap; flash-evaporator; etc.—Arthur S. LaPine & Co., 6001 S. Knox Ave., Chicago 29, Ill.

Circle **581** on inquiry card.

Incubators. New 4-page bulletin describes maker's anhydro and water-

jacketed incubators.—National Appliance Co., 7634 S. W. Capital Hwy., Portland 19, Oreg.

Circle **582** on inquiry card.

Freeze-drying. New 2-page data sheet describes maker's packaged "Model 3505" laboratory freeze-drying unit.—Naresco Equipment Corp., Newton Highlands 61, Mass.

Circle **583** on inquiry card.

ANALYTICAL

Electrolytic Conductivity. New 16-page Catalog 22 describes and illustrates maker's electrolytic conductivity equipment for measurement and control of solution concentration.—Industrial Instruments, Inc., 89 Commerce Rd., Cedar Grove, Essex County, N. J.

Circle **584** on inquiry card.

pH Meter. New 4-page illustrated Bulletin 911 describes maker's pH meter for measuring pH and millivoltages.—Cambridge Instrument Co., 3732 Grand Central Terminal, New York, N. Y.

Circle **585** on inquiry card.

pH Meter. New 4-page brochure describes maker's line-operated electronic pH meter "Model 110".—Photovolt Corp., 95 Madison Ave., New York 16, N. Y.

Circle **586** on inquiry card.

Viscosity Bath. New 2-page Bulletin 743 describes maker's redesigned "Model S" temperature-controlled kinematic viscosity bath.—Precision Scientific Co., 3737 W. Cortland St., Chicago 47, Ill.

Circle **587** on inquiry card.

RESISTORS, POTENTIOMETERS

Potentiometer Life. New 8-page Technical Paper 573 presents article on "Precision Potentiometer Life and Reliability".—Helipot Corp., 916 Meridian Ave., S. Pasadena, Calif.

Circle **588** on inquiry card.

Potentiometers. New 4-page leaflet describes maker's precision potentiometers, accelerometers, "Pitch-Yaw" indicator, etc.—Edcliff Instruments, 383 N. Foothill Blvd., Pasadena, Calif.

Circle **589** on inquiry card.

Rectilinear Potentiometer. New 2-page Bulletin C54-1 describes maker's "Type 2064" rectilinear-motion potentiometer.—Markite Corp., 155 Waverly Place, New York 14, N. Y.

Circle **590** on inquiry card.

Carbon Resistors. New 4-page Bulletin B-4a presents specifications and applications of maker's deposited carbon "Precistors."—International Resistance Co., 401 N. Broad St., Phila. 8, Pa.

Circle **591** on inquiry card.

Precision Potentiometer. New 4-page leaflet describes maker's "MP-10" potentiometer for basic measure-

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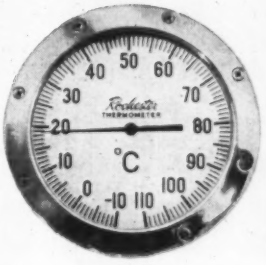

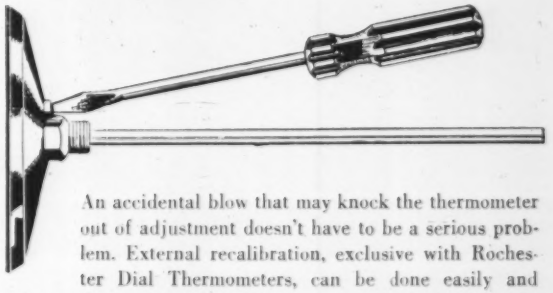

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For more information circle **126** on inquiry card.

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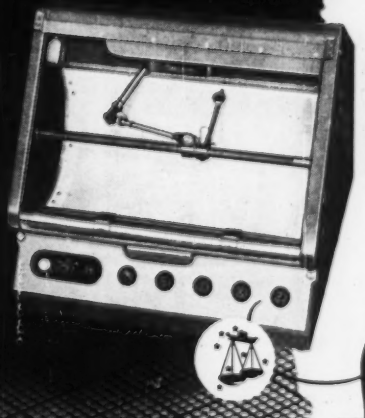

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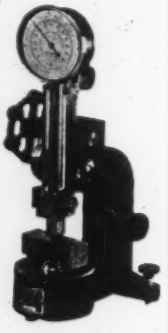

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For more information circle **129** on inquiry card.

NEW LITERATURE

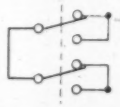
ment, analog multiplication, rotation to voltage tranducing, etc.—Analogue Controls, Inc., 30 E. 20th St., New York 10, N. Y.

Circle **592** on inquiry card.

Carbon Resistors. New 2-page Bulletin LL-2035 describes maker's line of deposited carbon resistors used in electrical and avionic applications.—Electroseal Products, Inc., 22 E. 40th St., New York 16, N. Y.

Circle **593** on inquiry card.

RELAYS, SWITCHES



Relay Manual. New 32-page Catalog R-522-4 covers principles of contacts, coils, arrangements, etc., and describes maker's extensive line of relays.—North Electric Co., Galion, Ohio.

Circle **594** on inquiry card.

Relays. New 4-page leaflet illustrates maker's subminiature relays for high-precision applications.—Elgin-Neomatic, Inc., 2435 North Naomi St., Burbank, Calif.

Circle **595** on inquiry card.

Relay System Testing. New 4-page booklet describes and illustrates maker's "Model 250F" functional tester for relay systems in aircraft and guided missiles.—DIT-MCO, Inc., 505 W. 9th St., Kansas City, Mo.

Circle **596** on inquiry card.

Control Relay. New 8-page Bulletin PL 7305-PM describes maker's line of sectional-pole heavy-duty 10-ampere control relays.—Clark Controller Co., 1146 E. 152nd St., Cleveland 10, Ohio.

Circle **597** on inquiry card.

Relays. New 2-page bulletin describes and illustrates maker's subminiature "IR 207" relays.—North Electric Mfg. Co., 601 S. Market St., Galion, Ohio.

Circle **598** on inquiry card.

Mercury Switches. New 2-page bulletin describes maker's magnetically-actuated mercury switches.—Hamlin, Inc., 1316 Sherman Ave., Evanston, Ill.

Circle **599** on inquiry card.

Relays. New 12-page leaflet lists maker's line of hermetically sealed relays, miniature, telephone-type, time-delay relays, etc.—Universal General Corp., 324 Canal St., New York 13, N. Y.

Circle **600** on inquiry card.

ELECTRICAL, ELECTRONIC INSTRUMENTS

Test Instruments. New 6-page leaflet describes and illustrates maker's pulse generator, sound-level indicator, high-speed level recorder, moisture meter, vacuum-tube voltmeter, stroboflash, balancing machines, and others in large line of British "Darve Instru-

ments."—Hickok Electrical Instrument Co., 10514 Dupont Ave., Cleveland 8, Ohio.

Circle **601** on inquiry card.

Test Equipment. New 16-page Catalog R-36A describes maker's test equipment for electronic measurements and industrial maintenance including voltmeters, ammeters, volt-ohm-milliammeters, VTVM's, oscilloscopes, etc.—Weston Electrical Instrument Corp., Newark 5, N. J.

Circle **602** on inquiry card.

Ohmmeters. New 4-page issue of "Instrument News" (Vol. 11, No. 3) describes uses of maker's "Ductor" low resistance ohmmeters.—James G. Biddle Co., 1316 Arch St., Phila. 7, Pa.

Circle **603** on inquiry card.

Frequency Recorder. New 8-page Bulletin B15-18 describes applications and operations of makers frequency recorder. Includes principles and mathematical analysis of circuit.—Minneapolis-Honeywell Regulator Co., Industrial Div., Phila. 44, Pa.

Circle **604** on inquiry card.

Null Indicator. New 4-page Bulletin NI illustrates and describes maker's "Model 2HG-1 Magnetik" null indicator, an electronic galvanometer with high-speed response.—Doelcam Div., Minneapolis-Honeywell, Soldiers Field Rd., Boston 35, Mass.

Circle **605** on inquiry card.

Precision Voltage Divider. New 2-page Data Sheet E-514(4) describes maker's precision voltage divider that is correct within ±1 part of 0.001% of the total.—Leeds & Northrup Co., 4934 Stenton Ave., Philadelphia 44, Pa.

Circle **606** on inquiry card.

Magnetic Test Set. New 4-page issue of "Electrical Measurements" (Vol. 22, No. 1) describes maker's magnetic testing set for B-H curves, hysteresis loops, etc.—Sensitive Research Instrument Corp., Mt. Vernon, N. Y.

Circle **607** on inquiry card.

Galvanic Voltmeter. New 2-page illustrated Bulletin 1-3 describes maker's "Model 610" dual-sensitivity voltmeter for measuring galvanic d-c potentials in corrosion control.—Associated Research, Inc., 3758 Belmont Ave., Chicago 18, Ill.

Circle **608** on inquiry card.

VTVM. New 2-page bulletin describes maker's "777" vacuum tube voltmeter.—Phaostron Co., 151 Pasadena Ave., S. Pasadena, Calif.

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R-F Instruments. Three new 2-page Bulletins BJE-621, BJE-622 and BJE-623 describe maker's "Model 77" indidental-frequency modulation meter "Model 62" slotted-line and VSWR indicator, and "Model 60" slotted-line R-F wattmeter.—Byron Jackson Co., P. O. Box 2017, Terminal Annex, Los Angeles 54, Calif.

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Signal Generator. Two new 2-page Bulletins BJE-624 and BJE625 de-

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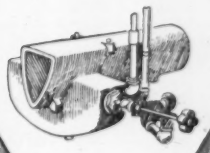

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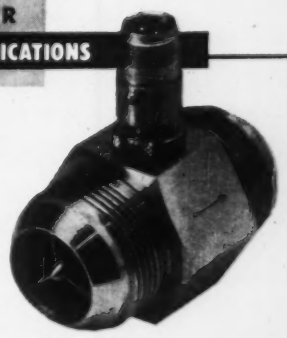

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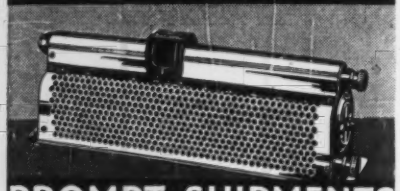

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NEW LITERATURE

scribe and illustrate maker's "Model 210" and "Model 30A" standard signal generators—Byron Jackson Co., P. O. Box 2017, Terminal Annex, Los Angeles 54, Calif.

Circle **611** on inquiry card.

Power Supplies. New 2-page bulletin describes maker's "R-10" super-regulated power supply (200-325 v dc at 100 ma).—Laboratory of Electronic Engineering, Inc., 413 L Street N. W., Washington, D. C.

Circle **612** on inquiry card.

Tachometers. Two new Bulletins (ET-955 and FC-955) describe and illustrate maker's electronic tachometers and frequency counters.—I-L-S Instrument Corp., 10701 Briggs Rd., Cleveland 11, Ohio.

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Circuit Analyzers. Two new 8-page leaflets picture and describe maker's "Model 80" circuit analyzers for testing cable systems.—Dit-Mco, Inc., 505 W. 9th St., Kansas City, Mo.

Circle **614** on inquiry card.

Delay Lines. New 8-page Technical Paper 491 features article on "Criteria and Test Procedures for Electromagnetic Delay Lines."—Helipot Corp., 916 Meridian Ave., South Pasadena, Calif.

Circle **615** on inquiry card.

Pulse Amplifier. New 16-page issue (Vol. 30, No. 2) of "Experimenter" features articles on pulse amplifier increasing utility of unit pulser, and Z-Y Bridge for a-f impedance measurement.—General Radio Co., 275 Massachusetts Ave., Cambridge 39, Mass.

Circle **616** on inquiry card.

Digital Phase Measuring. New 12-page Data File 107 describes method for precise phase measurement by digital technique.—Beckman Instruments, Inc., 2200 Wright Ave., Richmond 3, Calif.

Circle **617** on inquiry card.

Modulized Circuits. New 12-page descriptive Brochure MOD illustrates maker's modulized standard circuits—regulator, cathode follower, amplifier, driver, etc.—Aerovox Corp., 1200 Jefferson Davis Highway, Arlington, Va.

Circle **618** on inquiry card.

Panel Instruments. New 2-page illustrated bulletin describes maker's 1½" VU and DB panel instruments.—DeJur-Amsco Corp., 45-01 Northern Blvd., Long Island City 1, N. Y.

Circle **619** on inquiry card.

Facilities Brochure. New 16-page booklet BJE-608 describes and illustrates maker's working facilities for manufacture of electronic equipment.—Byron Jackson Co., P. O. Box 2017, Terminal Annex, Los Angeles 54, Calif.

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AIR, ATMOSPHERE

Dryers. New 40-page Bulletin D-100 describes maker's line of desiccant-type dryers for drying air, gases and liquids.—C. M. Kemp Mfg. Co., 405 E. Oliver St., Baltimore 2, Md.

Circle **621** on inquiry card.

Dehumidifier. New 2-page Bulletin 6551 describes maker's midget desiccant dryer for drying small flows of compressed gases to sub-zero dewpoints.—Industrol Corp., 472 Westfield Ave., E., Roselle Park, N. J.

Circle **622** on inquiry card.

Humidity Control. New 8-page Bulletin 2273 describes maker's humidity controller for humidifiers, lab test rooms, etc.—American Instrument Co., Inc., Silver Spring, Md.

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Nitrogen Generators. New 6-page illustrated Bulletin 1-100 describes maker's nitrogen generators for controlled furnace atmospheres.—C. M. Kemp Mfg. Co., 405 E. Oliver St., Baltimore 2, Md.

Circle **624** on inquiry card.

MECHANICAL COMPONENTS

Quartz Springs. New 2-page bulletin pictures and describes maker's fuzed quartz springs.—Houston Technical Laboratories, 2424 Branard, Houston 6, Tex.

Circle **625** on inquiry card.

Rubber Parts. New 4-page Catalog 5810 describes maker's custom-molded rubber parts.—Parker Appliance Co., 17325 Euclid Ave., Cleveland 12, Ohio.

Circle **626** on inquiry card.

Self-Sticking Letters. New 6-page Bulletin 165 pictures and describes maker's self-sticking, all-purpose numbers and letters.—W. H. Brady Co., 727 W. Glendale Ave., Milwaukee 12, Wis.

Circle **627** on inquiry card.

Fittings, Clamps. Three new 4-page Bulletins G 6-55 picture and describe maker's cable supports, junction boxes and housings, flexible conduit fittings, etc.—Adalet Mfg. Co., 14300 Lorain Ave., Cleveland 11, Ohio.

Circle **628** on inquiry card.

Plastic Products. New 4-page folder "Custom Plastic Service" describes development and design of plastic products.—Allegheny Plastics, Inc., Route 51 and Thorn Run Rd., Coraopolis, Pa.

Circle **629** on inquiry card.

Cemented Carbides. New 20-page Bulletin ST100 presents specifications of maker's cemented carbides for stone cutting tools.—Carboloy Dept., General Electric Co., Detroit 32, Mich.

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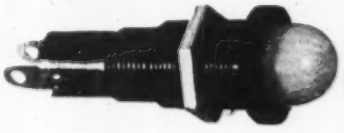

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NEW LITERATURE

FABRICATION

Packaging Machine. New 2-page bulletin pictures and describes maker's high-speed electronic counting and packaging machine.—Delta Engineering Corp., 88 Broad St., Boston 10, Mass.

Circle **631** on inquiry card.

Coil Winder. New 2-page Bulletin 510 pictures and describes maker's "Series 50" coil winder drive which handles solenoid coils up to 5 hp winding of field, mush, armature and similar coils.—Crown Industrial Products Co., 714 Amsterdam St., Woodstock, Ill.

Circle **632** on inquiry card.

Dividing Head. New 4-page bulletin describes maker's "CSI Model CS-65" dividing head for profiling, drilling, light milling, engraving dials, etc. —Custom Scientific Instruments, Inc., 541 Devon St., Kearny, N. J.

Circle **633** on inquiry card.

Wall Partitions. New 28-page booklet describes maker's "Unistrut" movable wall partitions for factories, warehouses, offices, etc.—Buchen Co., 400 W. Madison St., Chicago 6, Ill.

Circle **634** on inquiry card.

Petroleum Catalyst. New 4-page issue of "Newsletter" describes maker's "Sinclair-Baker RD 150" petroleum catalyst.—Engelhard Industries, 113 Astor St., Newark 5, N. J.

Circle **635** on inquiry card.

TELEMETERING

Telemetering Transmission Terminal. New 8-page leaflet describes maker's "Model 912 Comvor" data-transmission terminal for telemetering and remote supervisory control.—Radio Frequency Labs., Inc., Boonton, N. J.

Circle **636** on inquiry card.

Beacon Telemetering System. New 18-page bulletin presents technical description of Beacon Telemetering System developed for Army Signal Corps.—Stavid Engineering, Inc., U.S. Route #22, Plainfield, N. J.

Circle **637** on inquiry card.

WATER, WASTE

Water Treatment. New 24-page Bulletin BIF6 describes maker's "Blue Chip" instruments for water, sewage and waste treatment.—B-I-F Industries, Inc., 345 Harris Ave., Providence, R. I.

Circle **638** on inquiry card.

Chlorinator. New 16-page Catalog 70-10 describes maker's Figure 1050A chlorinator for purifying water supplies, treating sewage and industrial wastes, etc.—Fischer & Porter Co., 539 Jacksonville Rd., Hatboro, Pa.

Circle **639** on inquiry card.

Water-System Control Centers. New 8-page Bulletin 4178 presents typical assemblies of maker's conventional- and graphic-type cubicles for water

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system control, and installations in various industries.—Permutit Co., 330 W. 42nd St., New York 36, N. Y.

Circle **640** on inquiry card.

ELECTRONIC COMPONENTS

Variable Inductors. New 12-page Catalog 9/55 describes maker's "Vari-L" electrically variable inductors.—Vari-L Co., Inc., 432 Fairfield Ave., Stamford, Conn.

Circle **641** on inquiry card.

Connectors, Adapters, R-F Components. New 100-page Catalog 9 is a reference manual for determining what connector or component should be used for various applications. Includes cross-index of IPC, A-N and D-K numbers.—Industrial Products Co., Div. of Danbury-Knudsen, Inc., Danbury, Conn.

Circle **642** on inquiry card.

Printed-Circuit Connectors. New 2-page descriptive bulletin presents specifications on maker's "Series P-C" printed-circuit connectors.—DeJur-Amsco Corp., 45-01 Northern Blvd., Long Island City 1, N. Y.

Circle **643** on inquiry card.

Connectors. Two new 2-page bulletins describe maker's "Series P-C and GS" rectangular and printed-circuit connectors.—DeJur-Amsco Corp., 45-01 Northern Blvd., Long Island City 1, N. Y.

Circle **644** on inquiry card.

Couplers. New 4-page issue of "HP Journal" (Vol. 7, No. 2) features article on "High-Directivity Coaxial Directional Couplers and Reflectometers."—Hewlett-Packard Co., 275 Page Mill Rd., Palo Alto, Calif.

Circle **645** on inquiry card.

Transistors. Seven new 2-page Technical data sheets cover maker's "Types 2N130, 2N131, 2N132 and 2N133" germanium transistors.—Raytheon Mfg. Co., Newton 58, Mass.

Circle **646** on inquiry card.

Coils. New 2-page bulletin describes maker's "Types 1000 and 1100" adjustable coils for video peaking, color TV circuits, etc.—North Hills Electric Co., Inc., 203-18 35th Ave., Bayside 61, N. Y.

Circle **647** on inquiry card.

TV Transformers. New Catalog G-25 describes complete line of TV replacement transformers including horizontal and vertical outputs, deflection yokes, linearity or width coils, etc.—Gramer-Halldorson Transformer Corp., 2734 N. Pulaski Rd., Chicago 39, Ill.

Circle **648** on inquiry card.

Terminals. New 4-page Bulletin AVP pictures and describes maker's "ADVAC" high-voltage terminals.—Advanced Vacuum Products, Inc., 18-22 Liberty St., Stamford, Conn.

Circle **649** on inquiry card.

Wires, Cables. New 2-page bulletin describes maker's "Handypak" assortment of hook-up and test lead wire and dial cables. Birnbach Radio Co., Inc., 145 Hudson St., New York 13, N. Y.

Circle **650** on inquiry card.

Hermetic Seals. New 40-page brochure describes and illustrates maker's line of "Type S" glass insulated connectors.—Seals, Inc., 1010 Mission St., S. Pasadena, Calif.

Circle **651** on inquiry card.

Insulating Tubing, Wires, Markers. New 46-page illustrated catalog describes maker's "Turbo" brand electrical-electronic insulating tubing, wire-cable and identification markers. Includes appendix of terms and temperature-conversion tables.—William Brand & Co., Inc., Willimantic, Conn.

Circle **652** on inquiry card.

RF Cables. New 2-page bulletin describes maker's "JT" radio-frequency cables.—Times Wire and Cable Co., Inc., 48 State St., Meriden, Conn.

Circle **653** on inquiry card.

TUBE FITTINGS

Tube Fittings. New 20-page Catalog 4301 presents dimensional data on maker's tube fittings including: straight-thread fitting with O-ring sealing; "Triple-lok" flare and "Ferulok" flareless types.—Parker Appliance Co., 17325 Euclid Ave., Cleveland 12, Ohio.

Circle **654** on inquiry card.

Hose Couplings. New 20-page catalog describes maker's "Quick-Seal" line of quick-connect-disconnect hose couplings.—Titeflex, Inc., 10 Hendee St., Springfield 4, Mass.

Circle **655** on inquiry card.

PATENTS

Patents. New 20-page booklet "Preparing for Patent-Hood" describes various steps necessary in processing a patent application. Also brief description of "Increductor" controllable inductors.—CGS Laboratories, Inc., 391 Ludlow St., Stamford, Conn.

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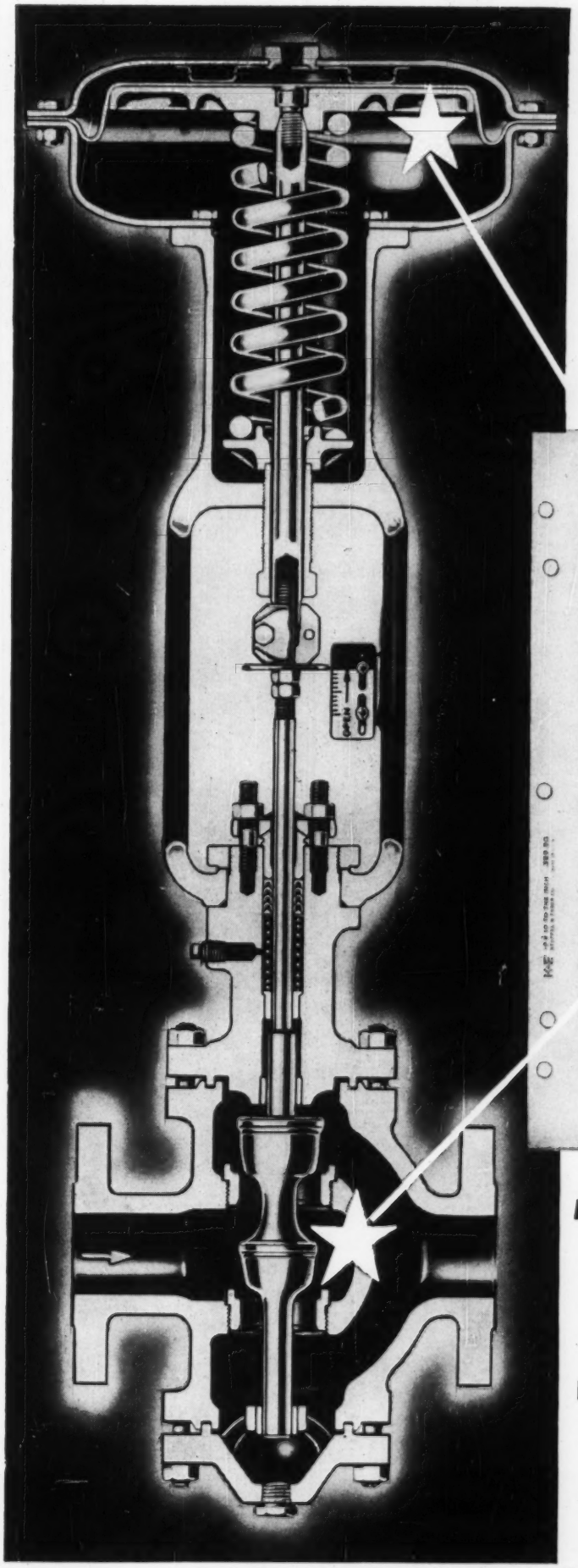

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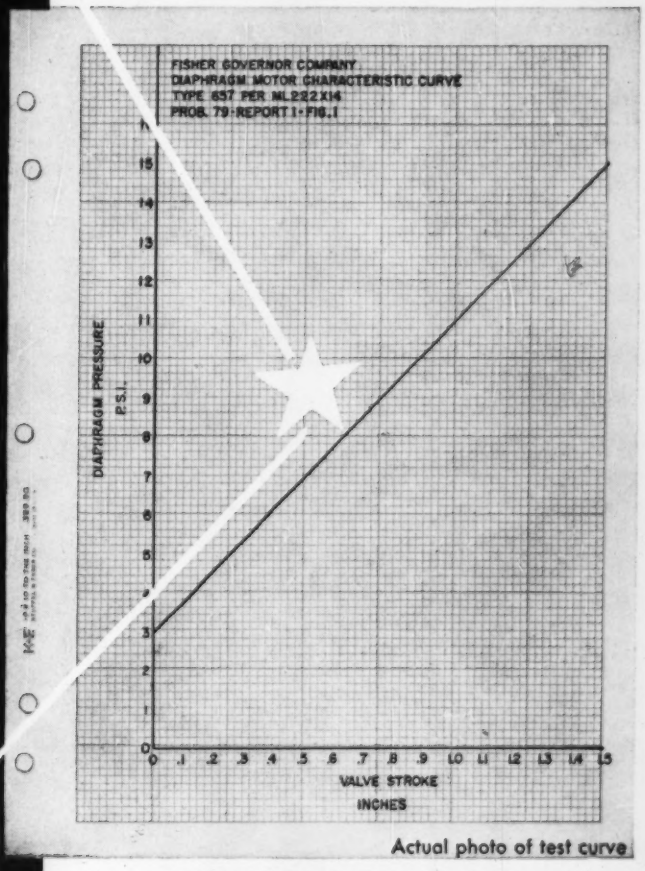

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